

CAPACITANCE BRIDGE
MODEL CB61
OPERATING AND INSTRUCTION MANUAL

WARNING

THIS ELECTRICAL INSTRUMENT MUST BE OPERATED AND USED ONLY BY TRAINED, QUALIFIED PERSONNEL. MISUSE OF ELECTRICAL INSTRUMENTS CAN RESULT IN PERSONAL ELECTRICAL SHOCK HAZARD AND/OR DAMAGE TO OTHER APPARATUS. READ INSTRUCTIONS AND UNDERSTAND THEM COMPLETELY BEFORE USING INSTRUMENT.

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TABLE OF CONTENTS

<u>Description</u>	<u>Section</u>
Introduction	A
Safety Precautions	B
Receiving Instructions	C
Specifications	D
Control & Connector Identification	F
Connections & Setting Up	G
Operating Procedure	H
Applications Test Connections and Test Reports	I
Trouble Shooting and Repair	J
Repair, Adjustment and Calibration	K

SECTION A

INTRODUCTION

1. GENERAL DESCRIPTION

Capacitance and Dissipation Factor Test Sets are self-contained test sets designed for field and shop testing of electrical insulating materials and system at voltages of up to 12 kV. The Test Sets are useful for evaluating the nature and quality of electrical insulation materials and systems, manufacturing processes, and for revealing contamination, fractures, punctures, and other defects which accompany the aging of insulation.

The Test Sets are fully shielded and guarded and measure the capacitance and dissipation factor of test specimens that may be grounded (GST) or ungrounded (UST). For easy transportability the Test Sets are assembled in two separate cabinets, Bridge and Power Supply.

2. APPLICATIONS

The test cells are capable of measuring:

- . Capacitance and Dielectric Losses (Dissipation Factor) of electrical insulation on high voltage power equipment such as cables, bushings, switchgear, transformers, rotating machines and capacitors.
- . Change of capacitance and dielectric loss of electric insulation due to variations with voltage level and ambient conditions, e.g. changes in temperature, humidity, pressure, mechanical shock, vibration and stress.
- . Dielectric constant.
- . Transformer exciting current.

3. FEATURES

- . Direct reading for Capacitance and for Dissipation Factor at 60 Hz or 50 Hz.
- . Bridge measuring circuit based on principle of opposing ampere turn balance using adjustable transformer-ratio arms.
- . Permanent calibration since accuracy is based primarily on transformer turn ratio and loss free standard capacitor.

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- . Bridge measuring circuit based on principle of opposing ampere turn balance using adjustable transformer-ratio arms.
- . Permanent calibration since accuracy is based primarily on transformer turn ratio and loss free standard capacitor.
- . Maximum operator safety as all Test Set controls are at ground potential.
- . Suitable for 2-terminal or 3-terminal measurements on both ungrounded (UST) and grounded(GST) specimens.
- . Provided with selector switch for changing the Test Set for UST to GST measurements.
- . Dual low voltage output cables to simplify measurements on multi-winding transformers.
- . Auxiliary high current output tap for use in measurement of transformer excitation current.

3. FEATURES (Cont.: -)

- . Maximum operator safety as all Test Set controls are at ground potential.
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- . Provided with selector switch for changing the Test Set for UST to GST measurements.
- . Dual low voltage output cables to simplify measurements on multiwinding transformers.
- . Auxiliary high current output tap for use in measurement of transformer excitation current.
- . Provided with 2 channel phase sensitive null detector which allows independent balancing of capacitance and dissipation factor controls.
- . Three level interference suppressor circuit, synchronized with the detector C and DF controls, allows for suppression of power frequency interference signals of up to $\pm 50\%$ in magnitude, both in phase and in quadrature to the bridge supply.
- . Bridge is provided with built-in overvoltage protective devices to prevent damage in the event of specimen breakdown.
- . Thermal overload relay protects the power transformer from damage due to overheating.
- . "Short" position provided on bridge for protection when raising voltage on a specimen of questionable insulation.
- . Low impedance transformer-ratio arms plus fully shielded and guarded circuits which shield all critical internal assemblies, connections and external cable essentially eliminate the influence of stray capacitances to ground.
- . Condensed operating procedure marked on bridge and power supply panels.

NOTE: This Test Set can produce and contains dangerous voltage. Before setting up or operating this equipment, read Section B of this manual.

SECTION B

SAFETY PRECAUTIONS

-SAFETY IS THE RESPONSIBILITY OF THE USER-

-LA SAGURIDAD ES EL CARGO DEL OPERADOR-

The Test Set and the specimen to which it is connected are a source of high-voltage electrical energy and all persons making or assisting in the tests must use all practical safety precautions to prevent contact with energized parts of the test equipment and associated circuits.

Persons actually engaged in the test must stand clear of all parts of the complete high-voltage circuit unless the set is de-energized and all parts of the test circuit are grounded.

Any persons not directly associated with the work must be kept away from test activities by suitable barriers, barricades or warnings.

Treat all terminals of high-voltage power equipment as a potential electric shock hazard. Remember that there is always the possibility of voltages being induced at their terminals because of proximity to energized high-voltage lines or equipment. Always disconnect test cables from power equipment before attempting to disconnect them at the Test Set.

On termination of a test, always gradually reduce the test voltage to zero before the Power Supply is turned OFF. The terminals of the test specimen should be short circuited by means of a safety ground ("hot stick") to solidly ground all live parts. Ground bonds should then be applied and left in place.

If the Test Set is properly operated and all grounds correctly made, no rubber gloves are necessary. As a routine safety procedure, however, some users require the use of rubber gloves, not only in making connections to the high-voltage terminals, but in manipulating the controls.

Corrective maintenance must be performed only by a person who is familiar with the construction and operation of the Test Set and the hazards involved.

SECTION C

RECEIVING INSTRUCTIONS

Your Capacitance and Dissipation Factor Test Set has been thoroughly tested and inspected to rigid inspection specifications before being shipped and is ready for use after it is set up as indicated in the Operating Section. Check the equipment received against the packing list. Notify OLMAN INSTRUMENTS or AGENT of any shortage of materials. The Test Set should be examined for damage received in transit. If any damage is found, file a claim with the carrier at once and notify OLMAN INSTRUMENTS' nearest representative giving a detailed description of the damages observed.

Section M - WARRANTY

Olman Instruments Limited warrant this instrument sold by us or our authorized agents, to be free from defects in material and workmanship for a period of 12 months from date of shipment. During the warranty period, Olman Instruments will, at our option, repair or replace the Instrument or part thereof which proves to be defective providing:

- (1) The Instrument is returned properly packed and transportation prepaid with prior authorization to us or our appointed agent,
- (2) The Instrument has not been altered, modified or repaired by unauthorized personnel and,
- (3) That our examination discloses to our satisfaction that any improper use, negligence or accident, exceeding environmental limits, or connecting the instruments to incompatible equipment.

This warranty is exclusive and is given and accepted in lieu of all other warranties, express or implied and constitutes fulfillment of all our liabilities to the purchaser. Olman Instruments specifically disclaims the implied warranties of merchantability and fitness for a specific purpose. We assume no liability, in any event, for consequential damages, for anticipated or lost profits, for personal injury due to use or accident, for incidental damages or loss of time or other losses incurred by the purchaser or any third party in connection with instruments covered by this warranty or otherwise.

REPAIRS

OLMAN INSTRUMENTS maintains a complete instrument repair service. Should this instrument ever require repairs, we recommend it be returned to the factory for repair by our instrument specialists. When returning instruments for repairs, either in or out of warranty, they should be shipped Prepaid and Insured, and marked for the attention of the Instrument Service Manager.

SECTION D

SPECIFICATIONS

1. CAPACITANCE & DISSIPATION FACTOR BRIDGE

1.1 Capacitance Measuring:

Ranges:

0 to 1.2 microfarads in 13 ranges (120/240/600/1200/2400/6000pF and 0.012/0.024/0.060/0.12/0.24/0.60/1.2 microfarads at full scale).

Limit of Error:

±(1% of reading + 2pF) Ungrounded Specimen Tests
±(1% of reading + 6pF) Grounded Specimen Tests

Resolution:

0.01% of range selected.

Sensitivity:

Sufficient to resolve 0.01% of range selected, at test voltages of 1000V rms.

1.2 Dissipation Factor (D.F.) Measuring:

<u>RANGE</u>	<u>LIMIT OF ERROR</u>	<u>RESOLUTION</u>
0 to 1.2%	±(2% of rdg + 0.02% D.F.)	0.001%
0 to 12%	±(2% of rdg + 0.05% D.F.)	0.01%
0 to 120%	±(2% of rdg + 0.5% D.F.)	0.1%

Sensitivity:

0.002% D.F. decreasing to 0.02% D.F. at a test voltage of 1 kV rms, as capacitance indications change from 100% to 10% f.s. respectively of the range used.

1.3 Bridge Circuit

Bridge circuit based on principle of opposing ampere turn matching using adjustable transformer-ratio arms. A third winding is used for the null detector signal.

1. CAPACITANCE & DISSIPATION FACTOR BRIDGE (Cont.: -)

1.4 Null Detector

Two channel phase sensitive (C, DF) null detector, with zero center meter, allows independent transformer-ratio arms. A third winding is used for the null detector signal.

Sync Control: Allows exact tuning of null detector.

Gain Control: Allows 100 to 1 gain reduction of null detector.

1.5 Interference Suppression

Low, medium, and high range interference suppressor circuit allows approximately ± 0.5 , ± 10 and $\pm 50\%$ suppression at full range and 12 kV for power frequency interference signals. Separate C and DF controls allow independent suppression of the interference current which is in phase and in quadrature to the bridge current.

2. POWER SUPPLY

2.1 Output Voltage

0 to 12 kV 50/60 Hz maximum continuous.

2.2 Output Current

Capacitance & DF Measurements at 0 to 12 kV

0 to 100mA continuous.

200mA for 15 minutes.

Transformer Exciting Current Measurements

at 0 to 2.4 kV

0 to 500mA continuous.

1000mA for 15 minutes.

2.3 Voltmeter

3½ digit L.C.D. voltmeter with 10 volt resolution, average responding RMS Calibrated.

2.4 Milliammeter

3½ digit L.C.D. milliammeter with 1mA resolution, average responding RMS Calibrated.

2. POWER SUPPLY (Cont.:--)

2.5 Reference Capacitor

Included in Power Supply: 100 pF $\pm 2\%$, SF₆ gas filled and loss free.

2.6 Guarding

Cold guard type circuit.
Guard circuit encloses transformer, reference capacitor, entire high voltage circuit and output test cables.

2.7 Power Transformer

Double shielded construction, sealed and SF₆ gas insulated. Normal operating pressure 5 to 10 psi gauge.

2.8 Test Mode Switch Positions

- | | |
|----------------------------|---|
| 1. UST R | Ungrounded specimen test, measures Hi to red Lo lead. |
| 2. UST B | Ungrounded specimen test, measures Hi to blue Lo lead. |
| 3. UST R+B | Ungrounded specimen test, measures Hi to red Lo plus Hi to blue Lo leads. |
| 4. GST R+B+G
(L Ground) | Grounded specimen test, measures Hi to red Lo plus Hi to blue Lo leads plus Hi to ground. |
| 5. GST G
(L Guard) | Grounded specimen test, measures Hi to ground. |
| 6. GST R+G
(L Guard) | Grounded specimen test, measures Hi to red Lo lead plus Hi to ground. |
| 7. GST B+G
(L Guard) | Grounded specimen test, measures Hi to blue Lo lead plus Hi to ground. |

2.9 Output Terminals

High voltage terminal marked C x H.
Low voltage (2 terminals), marked red and blue.
Transformer exciting current terminal marked 2.4 kV.
Bridge supply power.
External interlock (2 terminals)
Ground.

2. POWER SUPPLY (Cont.:--)

2.10 Input Power

120V, 60 Hz, 10A or 240V, 50 Hz, 5A, standard,
200V, 50 Hz on special order.

3. TEST CABLES (INCLUDED WITH TEST SET)

- . High Voltage test cable C x H, 15 kV, double shielded, 70 ft. lg.(20m)
- . Low Voltage test cables C x L, 2 kV, single shielded, 70 ft. lg.(20m) (2 cables, colour coded red and blue)
- . Bridge-power Supply interconnection cables, (2 cables)
- . Power Supply Input Cable, 3 conductor, 25 ft. lg.(7m)
- . Bridge Supply - Input Cable, 3 conductor, 8 ft. lg.(2m)
- . External Interlock Control Cable, with foot switch, 15 ft. lg.(5m)
- . Ground Cable, 15 ft. lg.(5m)
- . External Interlock Plug.

4. SAFETY FEATURES & OVERLOAD PROTECTION

- . Zero start for output voltage
- . External foot switch must be closed to energize the Test Set
- . Double ground required for Test Set to be energized. Amber indicating lamp for open ground
- . Indicating lamp (amber) for "power supply on" and two lamps (red) for "output voltage available"
- . All test set controls are at ground potential
- . No accessible energized terminals on outside of cabinets
- . Circuit breaker for short-circuit protection
- . Temperature operated relay for sustained overload protection. Amber indicating lamp for transformer overload
- . Overvoltage protective devices prevent damage to Bridge in event of specimen breakdown
- . Overvoltage operated relay limits power supply output voltage to 12 kV
- . "Short" position on bridge for protection when raising voltage on a specimen of questionable insulation or use as a basic safety procedure.

5. ENCLOSURE

Test Set is assembled in two separate cabinets, Bridge and Power Supply. Space is provided in Bridge cabinet for storage of Test cables.

Panel: off-white finish

Cabinet: Bench type instrument cabinet with textured finish. Cabinet has medium blue body and is trimmed in white.

6. DIMENSIONS

Bridge (Including Cables)

Dimensions: 17" high x 19-3/4" wide x 18" deep, approximately

Weight: Approximately 90 lbs.

Power Supply

Dimensions: 17" high x 19-3/4" wide x 18" deep, approximately

Weight: Approximately 92 lbs.

SECTION F

CONTROL & CONNECTOR IDENTIFICATION

The functions of the circuit components used in the operation of the test set are described below:

1. POWER SUPPLY

The control panel for the power supply has the following features. The location of the controls on the panel is shown in figure 3.

1.1 Main Switch

This three pole switch is used as ON/OFF in the power supply set. It also controls power supply to the capacitance bridge.

1.2 Circuit Breaker (rear panel)

Two circuit breakers, both one pole instantaneous overload trip, used for overload protection, connected in series to the Main Switch. Breakers are mounted on the rear panel of the power supply.

1.3 Open Ground Lamp

If the OPEN GROUND lamp comes ON, it indicates that the ground circuit in the U ground power cable is open, or that the power supply cabinet is improperly grounded by the ground cable. The lamp will also come ON in the event of a high resistance ground between the ground cable and the power cable ground. The power supply cannot be energized with high voltage with an Open Ground.

1.4 Red AC ON Lamp

This lamp is used to indicate that the proper circuit and the "Power" ON Switch is in the ON position and that the test set is energized from the line. It will not light when the circuit breaker is in the OFF position or when there is no power supplied to the Test Set.

1. POWER SUPPLY (Cont.: -)

1.5 ON Output Voltage Switch

This is a pushbutton switch which controls the operation of an internal line contactor and two HV ON red indicator lamps. External Interlock and Footswitch cables must be connected to their receptacles in the rear panel, Footswitch must be closed, the Voltage Control set to zero, the Open Ground and Transformer Overload lamps must be out, the OFF switch must be reset in order for the switch to perform its functions. When the switch is operated, the two HV ON red indicator lamps will light and test voltage may be applied by the Voltage Control.

1.6 Red HV ON Lamps

These two lamps are used to indicate that the test voltage is capable of being applied by clockwise rotation of the VOLTAGE CONTROL. They will light when the ON Output Voltage pushbutton switch is operated. They will go out and remain out if power is removed from the input of the test set, if the OFF Output Voltage pushbutton switch is operated, if the "POWER ON" or a proper breaker switch is turned off, if the footswitch is opened or the shorting plug is taken out of the External interlock receptacle, if the OPEN GROUND lamp is lit, or if the TRANSFORMER OVERLOAD lamp is lit.

1.7 Voltage Control

This control is a variable ratio auto-transformer used to adjust the output voltage of the test set by controlling the primary voltage of the power transformer. It functions in conjunction with a zero start switch which requires the control shaft to be in the counter-clockwise ("0") position prior to the ON Output Voltage switch becoming operative.

1.8 OFF Output Voltage Switch

This is a pushbutton switch which is used to de-energize the line contactor which turns off the test voltage. The red pilot lamps should go out when the OFF switch is operated. It performs the same function as opening foot switch.

Note: The OFF switch locks in the down position and must be reset by turning it clockwise before power can be applied again.

1. POWER SUPPLY (Cont.:--)

1.9 Transformer Overload Lamp

This is an amber lamp used to indicate thermal overload of the power transformer beyond the design limits. If extended overload should occur a thermal protective relay will operate causing the TRANSFORMER OVERLOAD lamp to come ON. The red pilot lamps should then go out. This performs the same reaction as opening a foot switch. The ON pushbutton switch will not function under this condition until the transformer temperature has returned to normal. At this time the overload relay will automatically reset, and it is indicated by the TRANSFORMER OVERLOAD lamp going out. The test set can then be re-energized by operation of the "POWER ON" switch.

1.10 Open Interlock Lamp

This amber lamp indicates the state of the external interlock, the lamp will be on if the interlock is open.

1.11 Test Mode Selector Switch

This is a seven position switch used for changing the test set from UST to GST measurements. It should be remembered that the test set always measures the capacitance from the CxH high voltage lead to the red Lo lead, the blue Lo lead or ground. The test set has the following test mode selections:

- | | |
|----------------------------|---|
| 1. UST R | Ungrounded specimen test, measures Hi to red Lo lead. |
| 2. UST B | Ungrounded specimen test, measures Hi to blue Lo lead. |
| 3. UST R+B | Ungrounded specimen test, measures Hi to red Lo plus Hi to blue Lo leads. |
| 4. GST R+B+G
(L Ground) | Grounded specimen test, measures Hi to red Lo plus Hi to blue Lo leads plus Hi to ground. |
| 5. GST G
(L Guard) | Grounded specimen test, measures Hi to ground. |
| 6. GST R+G
(L Guard) | Grounded specimen test, measures Hi to red Lo lead plus Hi to ground. |
| 7. GST B+G | Grounded specimen test, measures Hi to blue Lo lead plus Hi to ground. |

1.12 "FOOTSWITCH" and "EXTERNAL INTERLOCK"

These receptacles are located on the upper rear panel. 15 feet cable with a footswitch and a short-circuited interlock plug are connected to those receptacles.

1.13 CxH Receptacle

This is the high-voltage output terminal used for normal Capacitance and Dissipation Factor measurements. It is connected to the test specimen via the high-voltage test cable. The outer shield of this cable, terminated with a pig-tail lead, should be connected to the GROUND binding post.

1.14 Transformer Exciting Current Receptacle

This is a high-voltage output terminal, marked 2.4 kV, and is used when making excitation current measurements on transformer windings. It is connected to one end of a transformer winding via the high-voltage test cable. The outer shield of this cable, terminated with a pig-tail lead, should be connected to the GROUND binding post.

1.15 CxL BLUE and CxL RED Receptacles

These are low voltage coaxial terminals used for normal Capacitance and Dissipation Factor measurements. They are connected to the test specimen via the red and blue low voltage test cables.

Note: A single test cable is used when measuring a specimen which has only two terminals plus a ground.

1.16 Cx and Cn Receptacles

These coaxial terminals are used to interconnect the Bridge and Power Supply, via the two short coaxial cables, for normal Capacitance and Dissipation Factor measurements.

1.17 Input Receptacle

This receptacle is used to connect the power supply to an AC power source, via the power supply input cable.

Note: The power supply is universal and can be powered by 120 or 240V. 50/60Hz by the proper connection of the power cable.

1. POWER SUPPLY (Cont.:--)

1.18 Bridge Power

This receptacle is energized with line voltage when the "POWER ON" switch and the breakers are in the ON position, and is used to supply input power to the bridge via the extension and supplied with the set.

Note: Bridge power is always 120V regardless of the power supplied to the power supply.

1.19 Ground Terminals

Two wing-nut terminals on the lower rear panel are the power supply ground. The cabinet should be connected with the left hand wing-nut terminal to a good earth ground via the 15 foot ground cable supplied with the set. Right hand wing-nut terminal is used for connecting the outer shield of the high voltage test cable to ground.

2. CAPACITANCE & DISSIPATION FACTOR BRIDGE

The control panel for the Bridge has the following features. The location of the controls on the panel is shown in Figure 3.

2.1 Capacitance Multiplier Dial

This is a fourteen position rotary switch that permits selection of capacitance multiplier values of 1/2/5/10/20/50/100/200/500/1000 pF and .002/.005/.01 uF. The switch also has a SHORT position which is used when adjusting the DETECTOR SYNC control so that the phasing of the detector is exactly synchronized to the line voltage. This position is also useful for shorting out the bridge arm when raising voltage on a specimen of questionable insulation.

2.2 Capacitance Measuring Dials

These dials indicate directly the capacitance value of the test specimen, after taking into consideration the setting of the Capacitance Multiplier Dial. The measuring dial consists of two decade switches giving steps of 11(10 + 1) and a slidewire dial calibrated 0 to 1.1 to provide a total range of 122.1. The slidewire dial is subdivided into 50 steps of 0.02 and is easily adjustable to within a step of 0.01. The overlap portions of the second and third measuring dials are marked in red.

2. CAPACITANCE & DISSIPATION FACTOR BRIDGE (Cont.:--)

2.3 Dissipation Factor Multiplier Dial

This is a three position rotary switch, marked 0.1, 1 and 10, for selecting the Dissipation Factor multiplier value. This provides respective full scale measuring ranges of 1.2%, 12% and 120% D.F.

2.4 Dissipation Factor Measuring Dials

These dials indicate directly the Dissipation Factor (DF) value of the test specimen, after taking into consideration the setting of the Dissipation Factor Multiplier Dial. The measuring dials consist of a decade switch, giving 11 steps of 10% DF, and a slide-wire dial calibrated 0 to 1.1% DF, to provide a total range of 12.1% DF. The slidewire dial is subdivided into 50 steps of 0.02% DF, and is easily adjustable to within a step of 0.01% DF. The overlap portion of the slidewire dial is marked in red.

2.5 Null Detector

This is a two channel phase sensitive (C & DF) null detector which is used as the Bridge balance indicator when balancing the C & DF MEASURING dials, the C & DF INTERFERENCE SUPPRESSOR controls and DETECTOR SYNC control. The detector has a zero center meter which gives a sense of direction when balancing the Bridge.

2.6 Detector Sync Control

This control permits an exact tuning (or phasing) of the null detector so that the Bridge signal voltage is exactly synchronized to the line voltage. This feature allows for independent adjustment of the C & DF measuring dials with a minimum of interaction between dial adjustment. This minimizes, the commonly stated, sliding null effect.

2.7 Detector Gain Control

This control, is continuously adjustable, and allows adjusting the detector gain from full sensitivity to a 100:1 reduction of sensitivity.

2.8 Detector Phase (C & DF) Switch

This control, is used to switch the phase sensitive null detector between the C & DF channels. This control is used when selecting the phase of the Capacitance and Dissipation Factor measuring dials, as well as C & DF

2. CAPACITANCE & DISSIPATION FACTOR BRIDGE (Cont.: -)

2.8 Detector Phase (C & DF) Switch (Cont.: -)

Interference Suppressor controls. The "C" currents are in phase with the Bridge current, whereas the DF currents are in quadrature to the Bridge current.

2.9 Interference Suppressor (OFF, LO, MED & HI) Switch

This is a four position rotary switch which allows for the selection of a Low, Medium, or High range of the INTERFERENCE SUPPRESSOR circuit. This gives approximately a ± 0.5 , ± 10 and $\pm 50\%$ suppression, at full measuring range and at 12 kV, for power frequency interference signals. The OFF position, disconnects the INTERFERENCE SUPPRESSOR circuit, and is provided for measurements in the shop where power frequency interference signals generally do not present a problem.

2.10 "C" Interference Suppressor Control

This control allows for the independent suppression of the C power frequency interference current which is in phase to the Capacitance current.

2.11 DF Interference Suppressor Control

This control allows for the independent suppression of the DF power frequency interference current which is in quadrature to the Capacitance current (or in phase with the DF signal current).

SECTION G
CONNECTIONS & SETTING UP

1. GENERAL

The Test Set is assembled in two separate cabinets (Bridge and Power Supply) and must be interconnected before being energized. The test and interconnection leads are stored in the cabinet space under the Bridge. Open the rear door of the Bridge and carefully remove the leads.

It should always be remembered that the CxH lead (triaxial lead) is the high-voltage lead.

The CxL leads (coaxial leads with red and blue) are connected to the Bridge measuring arms and are the sensitive leads of the Bridge concerning the influence of stray capacitance.

2. SETTING UP THE TEST SET (CAPACITANCE & DF MEASUREMENTS)

Connect the test and interconnection leads to the Test Set as follows:

- 2.1 Connect the wing-nut ground terminal to a low impedance earth ground using the 15 foot ground cable supplied with the Test Set.
- 2.2 Using the two short leads of coaxial cable connect Cx of Bridge to Cx of Power Supply, and Cn of Bridge to Cn of Power Supply.
- 2.3 Connect the 70 foot long coaxial cable with red mark to the CxL RED terminal of Power Supply.
- 2.4 If required (Refer to Section I, Applications) connect the 70 foot long coaxial cable with blue mark to the CxL BLUE terminal of Power Supply.
- 2.5 Connect the 70 foot long high-voltage lead to the CxH terminal of Power Supply (Capacitance and Dissipation Factor Measurements). Connect the pigtail for the outer shield to the GROUND binding post.
- 2.6 Connect the 15 foot long control cable, with foot switch, to one of the terminals marked EXTERNAL INTERLOCK. A plug, short circuited with a removable jumper should be inserted in the remaining receptacle, however, this may also be used for connection to a safety interlock switch.

2. SETTING UP THE TEST SET(CAPACITANCE & DF MEASUREMENTS) (Cont.: -)

2.7 Connect the power input receptacle of the Bridge to the BRIDGE LINE receptacle of the Power Supply, using the 8 foot long extension cord supplied with the Test Set.

2.8 Connect the INPUT receptacle of the Power Supply to the AC power source, using the 25 foot long input power cable supplied with the Test Set.

Note: The source and end of the power supply cable is normally supplied without a plug. This cable must be properly wired to a plug of local usage. The power supply can be wired for 120, or for 240 volt operation as indicated on the rear panel of power supply.

IMPORTANT

The outer shells of the high-voltage receptacles are at GUARD potential. To allow measurements in the GST switch positions (4 to 7), the GUARD must not be grounded except through the instrument. It is therefore necessary to remove BOTH PROTECTIVE CAPS and make certain that the matalic chains do not touch the CxH cable connector.

3. SETTING UP THE TEST SET(TRANSFORMER EXCITATION CURRENT MEASUREMENTS)

The Power Supply only can be used for these tests.

Connect the test leads to the Test Set as follows:

3.1 Connect wing-nut ground terminal to ground tank of transformer using the 15 foot ground cable supplied with the Test Set.

3.2 Connect the terminal Cx to the terminal CxL Red using one of the short coaxial cable leads supplied with the Test Set.

3.3 Set the mode selector switch to position 5 or 7.

3. SETTING UP THE TEST SET(TRANSOFRMER EXCITATION CURRENT MEASUREMENTS)

- 3.4 Connect the transformer winding to the 2.4 kV terminal of the power supply with the high-voltage cable lead. Connect the pigtail for outer shield to the GROUND binding post.
- 3.5 Connect the other side of the transformer winding to the ground tank.
- 3.6 Connect the control cable and input power cable to the Power Supply as stated in steps 2.6 and 2.8 of previous sub-section.

Note: The test can also be set in the following manner:

- 3.2 Connect the terminal Cx to the terminal CxL Blue using one of the short coaxial cable leads supplied with the Test set.
- 3.3 Set the mode selector switch to position 5 or 6.

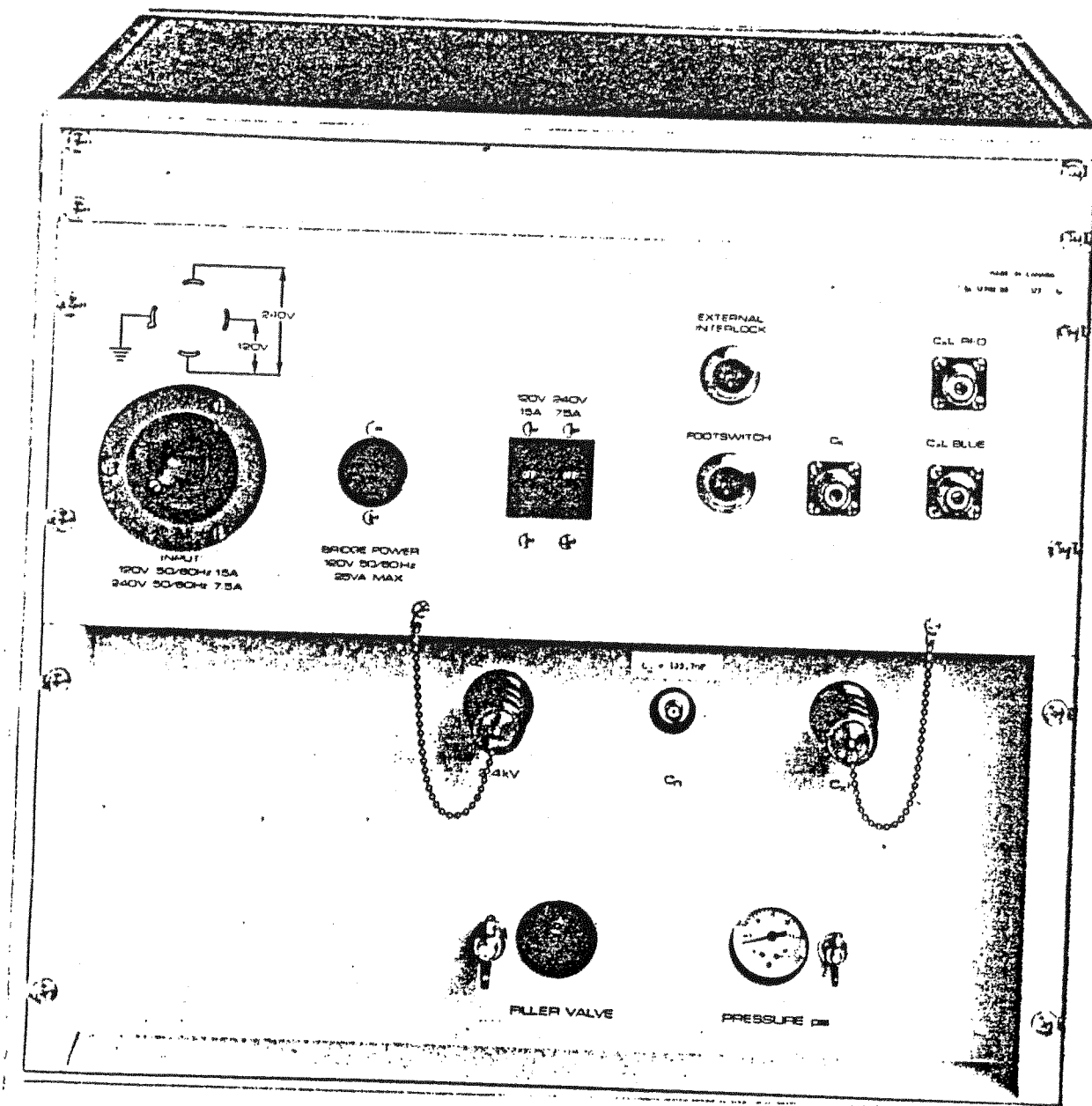


FIGURE 4: CONNECTOR IDENTIFICATION (POWER SUPPLY)

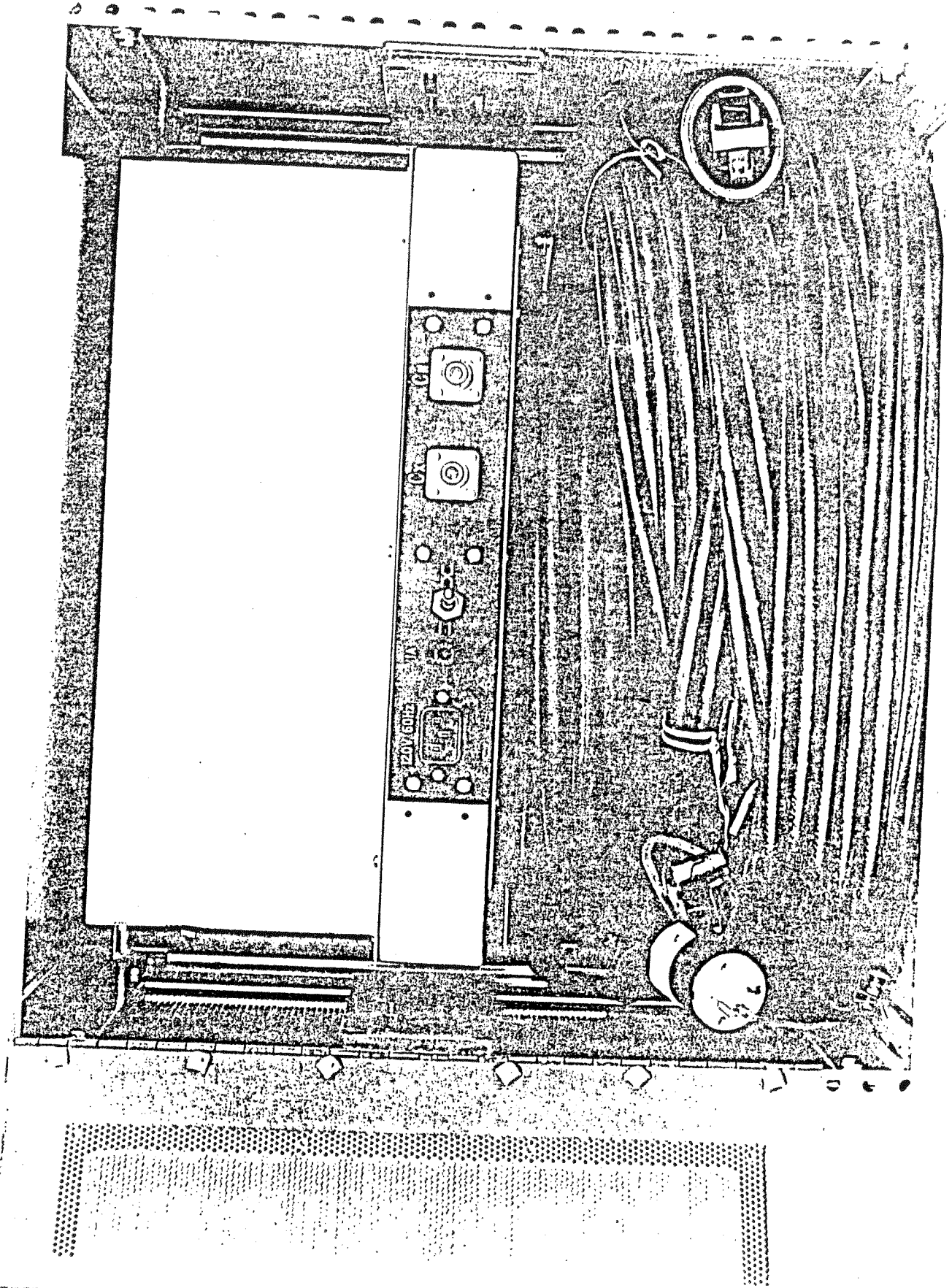


FIGURE 4a: CONNECTOR IDENTIFICATION (BRIDGE)

SECTION H
OPERATING PROCEDURE

1. GENERAL

Proceed only after fully understanding the Safety Precautions (Section B) and setting up the Test Set as described in the Connection Instructions (Section G) and Application instructions (Section I).

It is assumed at this point that the function of the controls and terminals (Section F) as well as the basic operation of the Test Set (Section 3) is fully understood.

The condensed operating instructions on the Power Supply and Bridge panels are intended only as a reminder of operating procedure. Before operating this Test Set, the following detailed instructions should be carefully read.

2. ENERGIZING THE TEST SET AND MAKING CAPACITANCE AND DISSIPATION FACTOR MEASUREMENTS

The following is a step-by-step procedure for conducting a test on a specimen.

- 2.1 Prior to energizing Test Set, check entire circuit to make sure that all connections have been properly made and Test Set has been properly grounded.

Ensure that specimen is de-energized and safe before making connections.

- 2.2 Open "POWER ON" switch and set VOLTAGE CONTROL to zero.

- 2.3 Set the Bridge controls to following initial settings:

C MULTIPLIER	SHORT
C DIALS	5, 5, 0
DF MULTIPLIER	0.1
DF DIALS	0
DETECTOR GAIN	MIDWAY
DETECTOR PHASE	DF
SUPPRESSOR RANGE	LOW
SUPPRESSOR C & DF DIALS	MIDWAY

- 2.4 Connect power supply to a suitable source of power. Close breakers on rear panel of power supply.

2. ENERGIZING THE TEST SET AND MAKING CAPACITANCE AND
DISSIPATION FACTOR MEASUREMENTS (Cont.:--)

- 2.5 Energize Test Set by closing "POWER ON" switch. The amber AC ON lamp should now be illuminated. If OPEN GROUND light comes ON, it indicates that the ground circuit in the power cable is open, or that there is a high resistance ground between the ground cable and power cable ground. The Test Set cannot be energized with high voltage with an open ground.
- 2.6 Set testmode selector switch to required UST-GST bridge configuration.
- 2.7 Insert a shorted plug to "EXTERNAL INTERLOCK" receptacle, connect a cable with a footswitch to the "FOOTSWITCH" receptacle, close a footswitch.
- 2.8 Set VOLTAGE CONTROL to "0" then depress ON OUTPUT VOLTAGE button. The two red lamps at the top of the panel should now be illuminated. If these lamps do not come on, check to see if the voltage control is turned down to "0", check if OFF switch is reset.
- 2.9 Advance VOLTAGE CONTROL to obtain desired test voltage.
- 2.10 Adjust DETECTOR SYNC control to bring null indicator to zero.

Note: If no reversal occurs when the range switch reaches 1 pF, the value of the capacitance is less than 55 pF, and the setting of the "C" MEASURING dials will have to be decreased to obtain a null.

If desired, the CAPACITANCE MULTIPLIER dial may be set at a convenient range just before reversal, in which case the setting of the "C" MEASURING dials will have to be decreased to obtain a null. It should be kept in mind however, that the first "C" MEASURING dial must always have at least 1 step in the circuit at balance if good accuracy is to be obtained.

- 2.13 Switch DETECTOR PHASE to DF position and adjust DF measuring dials to bring null indicator to zero. If detector indicator continues to swing to the left when at maximum setting, increase DF MULTIPLIER setting to the next higher range as required (i.e. 1 or 10).

Note: Omit this step when in presence of a strong interference field. Decrease detector GAIN if too much sensitivity is obtained.

2. ENERGIZING THE TEST SET AND MAKING CAPACITANCE AND
DISSIPATION FACTOR MEASUREMENTS (Cont.: -)

- 2.14 Steps 2.9 through 2.13 constitute a coarse balance of the Bridge.
- 2.15 Reduce the setting of the VOLTAGE CONTROL to "0" (not off).
- 2.16 Set DETECTOR PHASE to "C", then adjust "C" INTERFERENCE SUPPRESSOR Control for null. Switch to MED or HI range if required.
- 2.17 Set DETECTOR PHASE TO DF then adjust DF INTERFERENCE SUPPRESSOR Control for null. Switch to MED or HI range if required.
- 2.18 Switch back and forth from C to DF suppression to obtain a finer balance.
- 2.19 Advance VOLTAGE CONTROL to obtain desired test voltage.
- 2.20 Set DETECTOR PHASE to "C", then re-null "C" MEASURING DIALS.
- 2.21 Set DETECTOR PHASE to DF, then re-null DF MEASURING DIALS.
- 2.22 Switch back and forth from C to DF to obtain a finer adjustment of measuring dials.
- 2.23 Reduce setting of the VOLTAGE CONTROL to "0" then re-check balance of C & DF SUPPRESSOR Controls. Readjust if required.
- 2.24 Increase Bridge voltage to desired test value and re-adjust C & DF MEASURING dials if SUPPRESSOR Control was readjusted. For a perfect balance null indicator will be at zero in both C & DF phases and with bridge voltage at both zero and desired test value.
- 2.25 The sum of the Capacitance dials multiplied by the setting of the multiplier dial gives the capacitance value of the test specimen.
- 2.26 The sum of the Dissipation Factor dials multiplied by 0.1 for the 0-1% range; one for the 0-10% range; or 10 for the 0-100% range, gives the percent dissipation factor of the test specimen.

2. ENERGIZING THE TEST SET AND MAKING CAPACITANCE AND DISSIPATION FACTOR MEASUREMENTS (Cont.: -)

- 2.27 When test has been completed gradually reduce test voltage to zero, open footswitch or depress OFF OUTPUT VOLTAGE button, then turn power OFF with "POWER ON" switch. All lamps on the Power Supply should now be out.

WARNING: Discharge test specimen with a safety ground ("hot stick") to ground all live parts, then solidly ground these parts with a ground bond. Always disconnect test cables from power equipment before attempting to disconnect them at the Test Set.

2.28 Operating Hints:

Highest detector gain should be used only under favourable (shop) conditions. Use lower detector gain for field testing at the 10 kV level.

A perfect balance is difficult if not impossible to obtain in the presence of large power frequency interference signals, especially if the signals vary.

Use a higher "C" MULTIPLIER range to suppress the effects of interference pickup, or in the event either the C or DF Interference Suppression controls cannot be mullied when on their High range.

The Bridge UST-GST configuration may be changed with full test voltage applied to a specimen, however, care must be exercised to prevent damage to the specimen.

3. TRANSFORMER EXCITATION CURRENT MEASUREMENTS

To reduce the required charging current conduct all tests on high-voltage windings only. Shorted turns will still be detected in the low voltage windings.

Always apply the exact same test voltage to each phase of a three phase transformer winding. This will minimize errors due to any non-linearity between voltage and current. For this same reason subsequent tests on transformer windings, whether single or three phase, should always be repeated at the exact same test voltage.

Care should be exercised when energizing transformer windings so as not to exceed the voltage rating of the winding.

3. TRANSFORMER EXCITATION CURRENT MEASUREMENTS (Cont.: -)

The following is a step-by-step procedure for measuring transformer excitation current.

- 3.1 Ensure that transformer is de-energized and safe, and all loads disconnected before making connections.
- 3.2 Connect the Power Supply to the transformer winding as described in the Connection Instructions (Section G).

Note: The CxL RED lead is the grounded lead and should be connected to the Ho terminal in Wye-Connected transformer windings.
- 3.3 Prior to energizing Test Set, check entire circuit to make sure that all connections have been properly made and Test Set has been properly grounded.
- 3.4 Set test mode selector switch to position (5). This internally grounds the CxL RED test lead.
- 3.5 Energize Test Set by closing "POWER ON" switch.

Note: Excitation current measurements can be done at 12kV or 2.4kV range. In the latter case divide kV meter reading by 5.
- 3.6 Insert a shorting plug into EXTERNAL INTERLOCK terminal and a footswitch cable plug to the FOOTSWITCH terminal.
- 3.7 Set voltage control to "0".
- 3.8 Depress the footswitch.
- 3.9 Depress ON OUTPUT VOLTAGE pushbutton.
- 3.10 Advance VOLTAGE CONTROL to obtain desired test voltage.
- 3.11 Read value of transformer excitation current on mA meter scale.

Note: If BREAKER trips when advancing VOLTAGE CONTROL in step 3.10, the output capabilities of the power supply have been exceeded and it will be necessary to measure the transformer excitation current at a lower test voltage.
- 3.12 When test has been completed gradually reduce test voltage to zero, open footswitch or depress OFF OUTPUT VOLTAGE button, then turn power OFF with "POWER ON" switch. All lamps should be out.

W A R N I N G

Discharge transformer terminals with a safety ground ("hot stick") then solidly ground terminals with a ground bond. Always disconnect test cables from transformer terminals before attempting to disconnect them at the Test Set.

SECTION I

APPLICATIONS

1. GENERAL

Figures 6 and 7 illustrate the specific connections between the Test Set and specimen for each setting of the UST-GST mode selector switch.

Typical test report forms are illustrated in this section to facilitate the testing of transformers and circuit breakers. Also refer to Figures 8 through which schematically shows the typical test connections for this equipment.

The following chart shows the specific component of Capacitance and DF which is measured for each setting of the UST-GST mode selector switch, as well as how the Test Set automatically connects the low voltage red and blue CxL test leads, to either GUARD or GROUND, in the Bridge circuit. Measurements are always made between the CxH (black boot) high voltage lead and the lead called out in the MEASURES column.

If the specimen is a transformer, short each winding on itself.

UST-GST MODE SELECTOR SWITCH SETTINGS

UST

<u>TEST MODE</u>	<u>MEASURES</u>	<u>GROUND</u>
3	R	B
2	B	R
1	R+B	-

GST L-GROUND

<u>TEST MODE</u>	<u>MEASURES</u>	<u>GROUND</u>
4	R + B + G	R & B

GST L-GUARD

<u>TEST MODE</u>	<u>MEASURES</u>	<u>GUARDS</u>	<u>GROUND</u>
5	G	R & B	-
6	R + G	B	R
7	B + G	R	B

1. GENERAL (Cnt.:--)

1.1 Measuring a Specimen which has Two Terminals Plus a Ground

1.1.1 Connect ground lead to ground tank of specimen.

1.1.2 Connect CxH and CxL (red) leads to specimen as shown in Figure 6.

1.1.3 Set test mode switch to required position 3, 4, or 5.

1.1.4 Follow Operating Procedure described in Section H.

1.1.5 Capacitance & DF component measured is shown by solid line in Figure 6 schematic diagrams.

1.2 Measuring Specimen which has Three Terminals Plus a Ground

1.2.1 Connect ground lead to ground tank of specimen.

1.2.2 Connect CxH, CxL (red) and CxL (blue) leads to specimen as shown in Figure 7.

1.2.3 Set test mode switch to required position 1 through 7.

1.2.4 Follow Operating Procedure described in Section H.

1.2.5 Capacitance & DF component measured is shown by solid line in Figure 7 schematic diagrams.

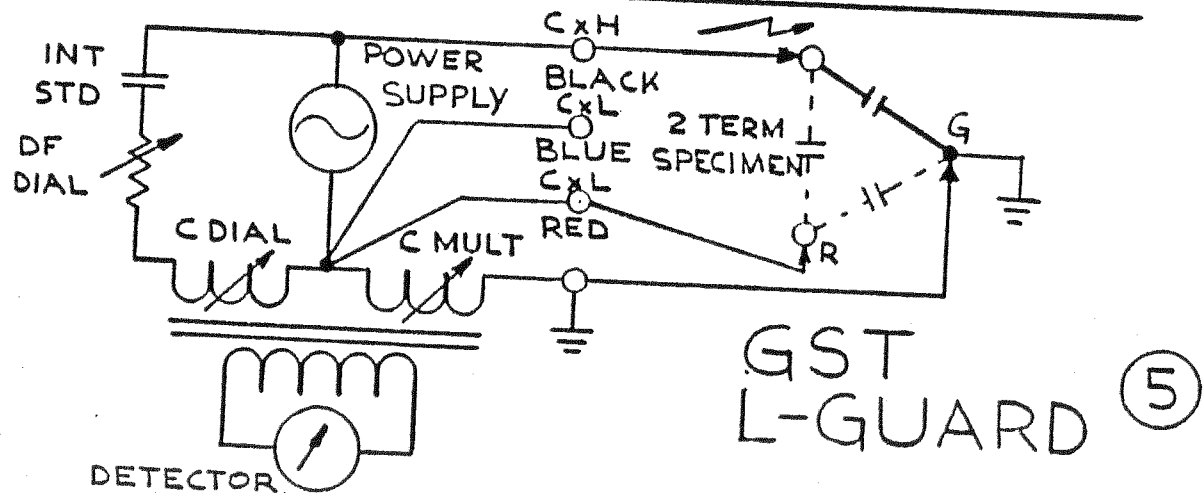
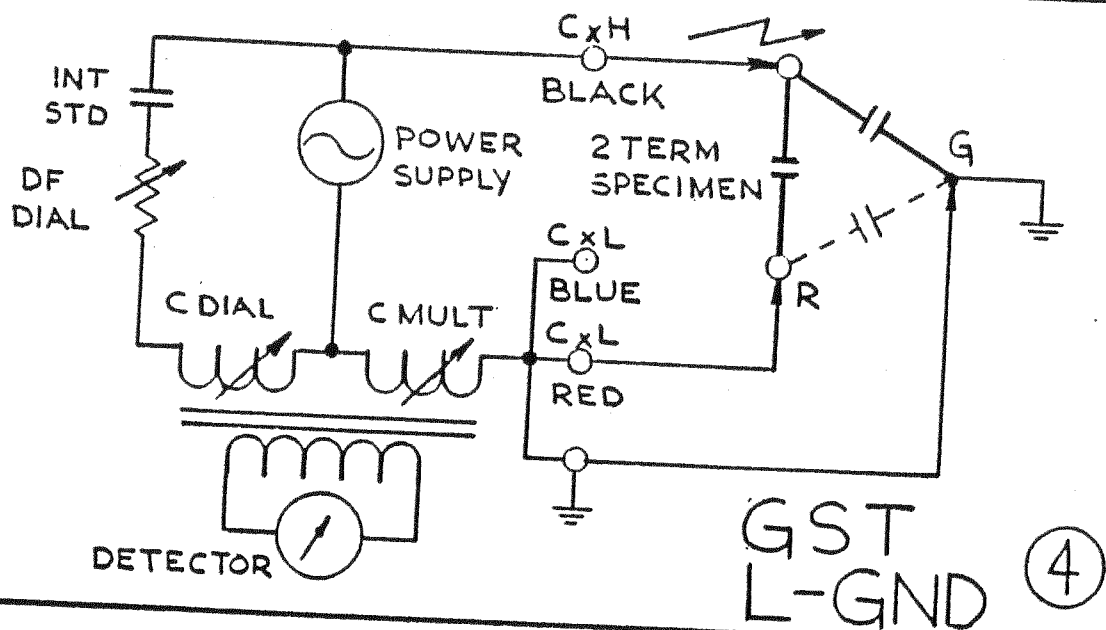
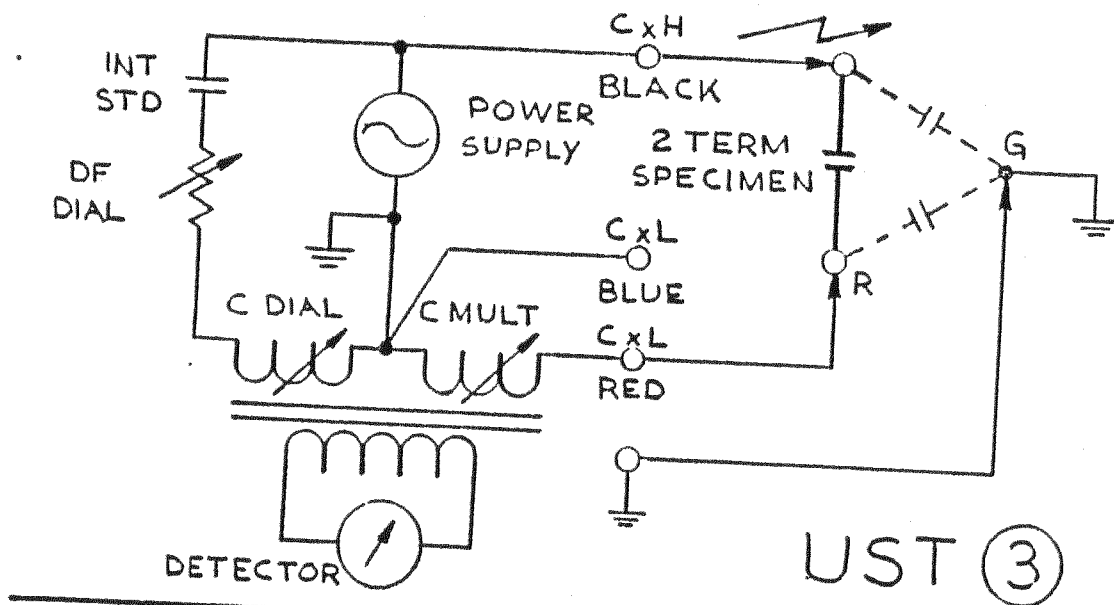


FIGURE 6: CONNECTION FOR TESTING TWO TERMINAL SPECIMEN.

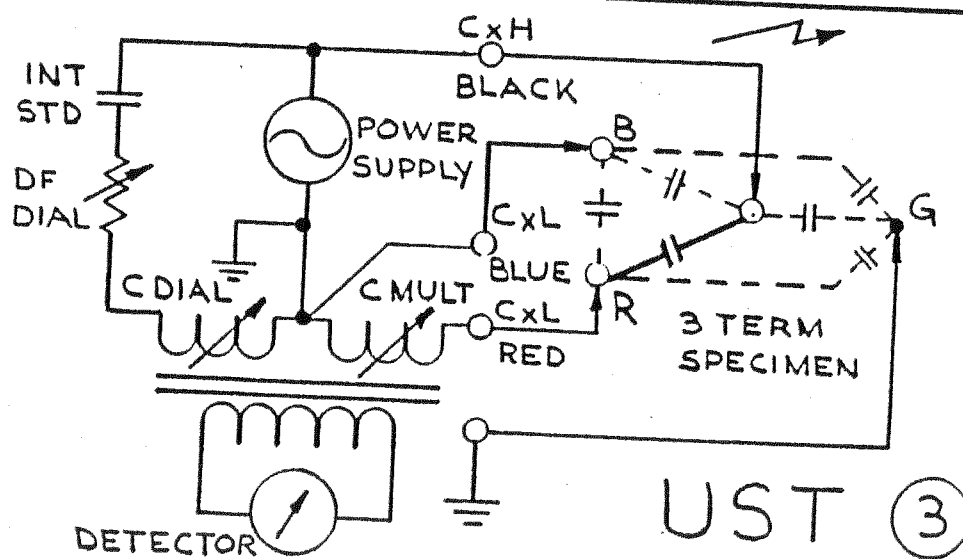
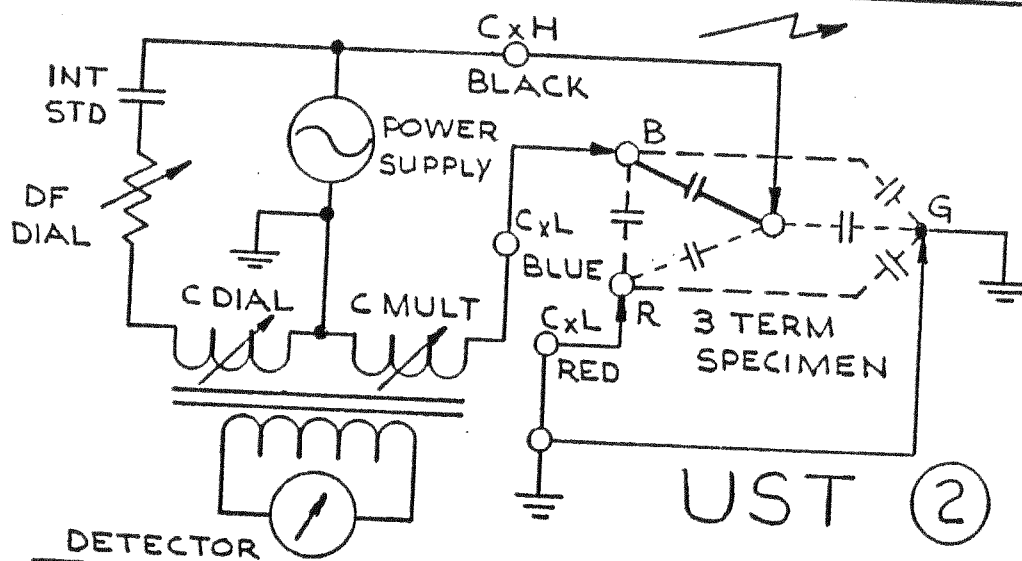
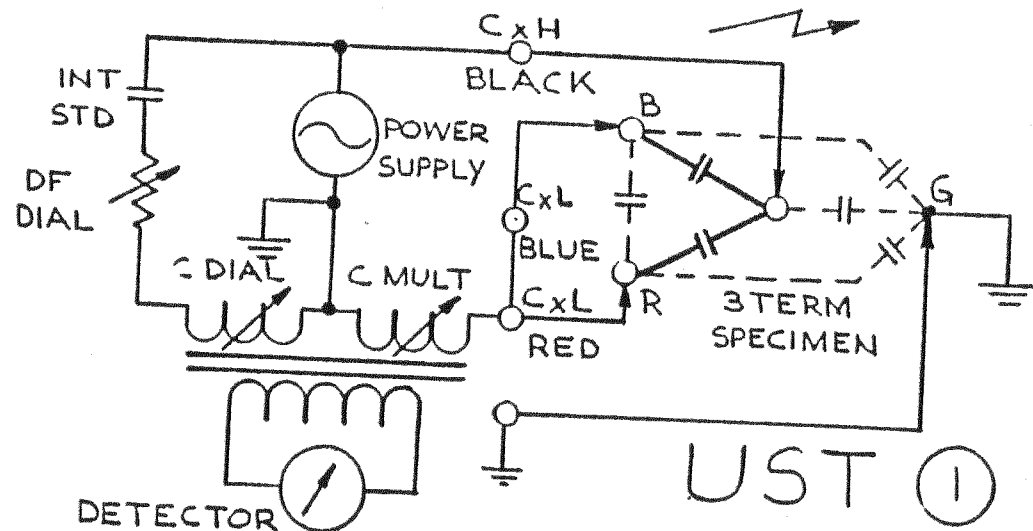


FIGURE 7a: CONNECTION FOR TESTING THREE TERMINAL SPECIMEN

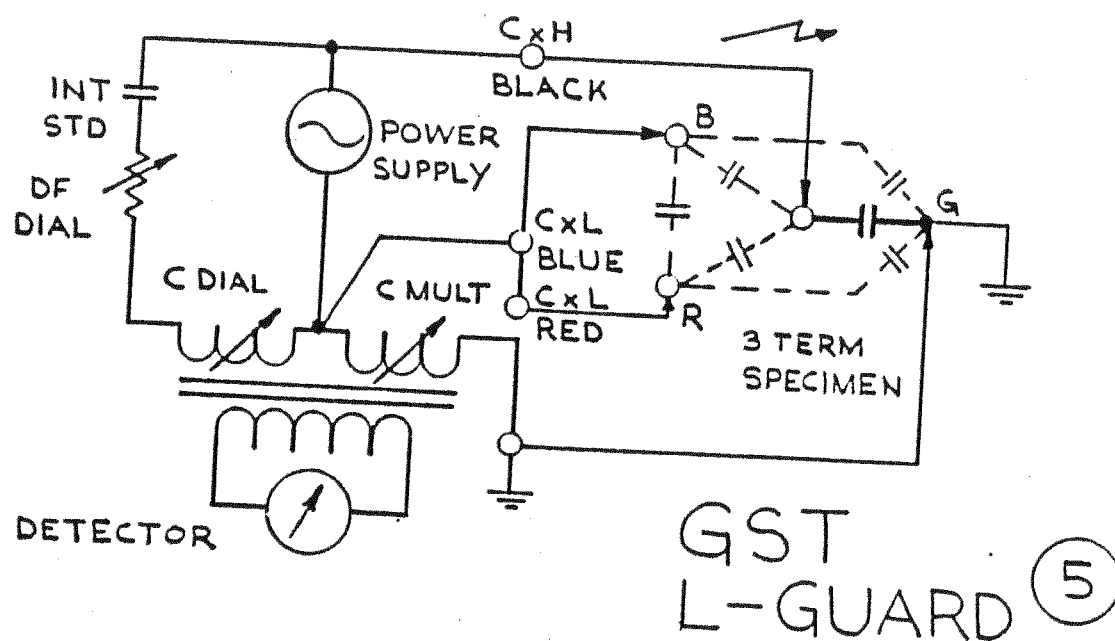
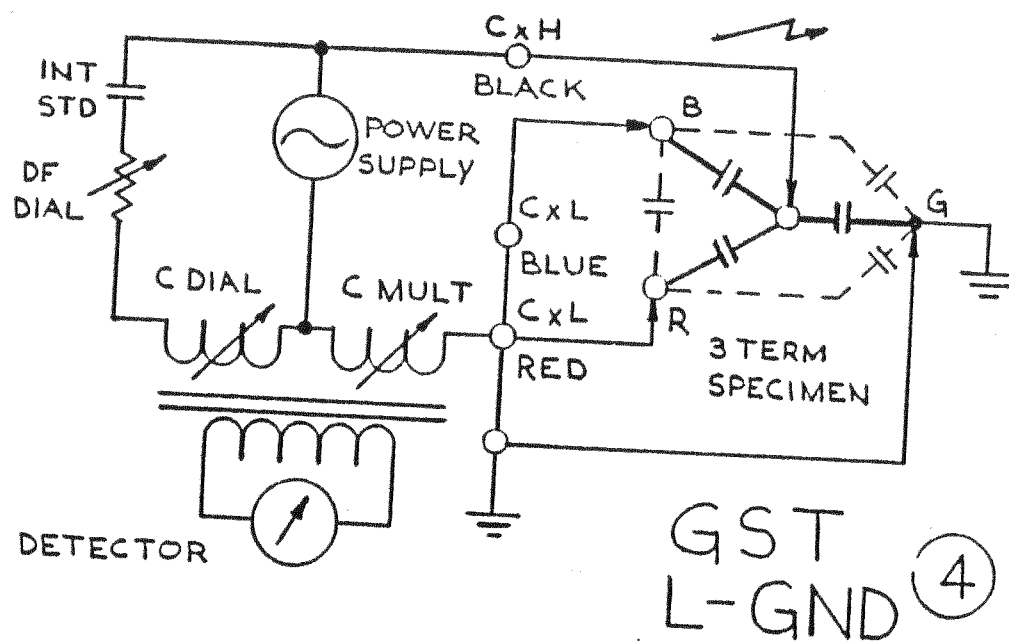


FIGURE 7b: CONNECTION FOR TESTING THREE TERMINAL SPECIMEN

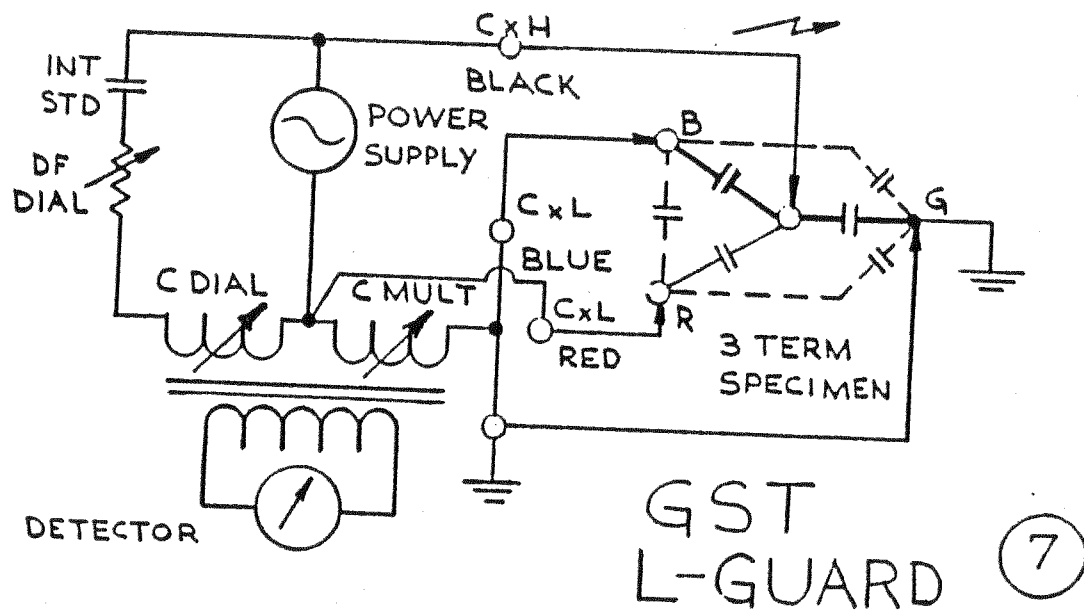
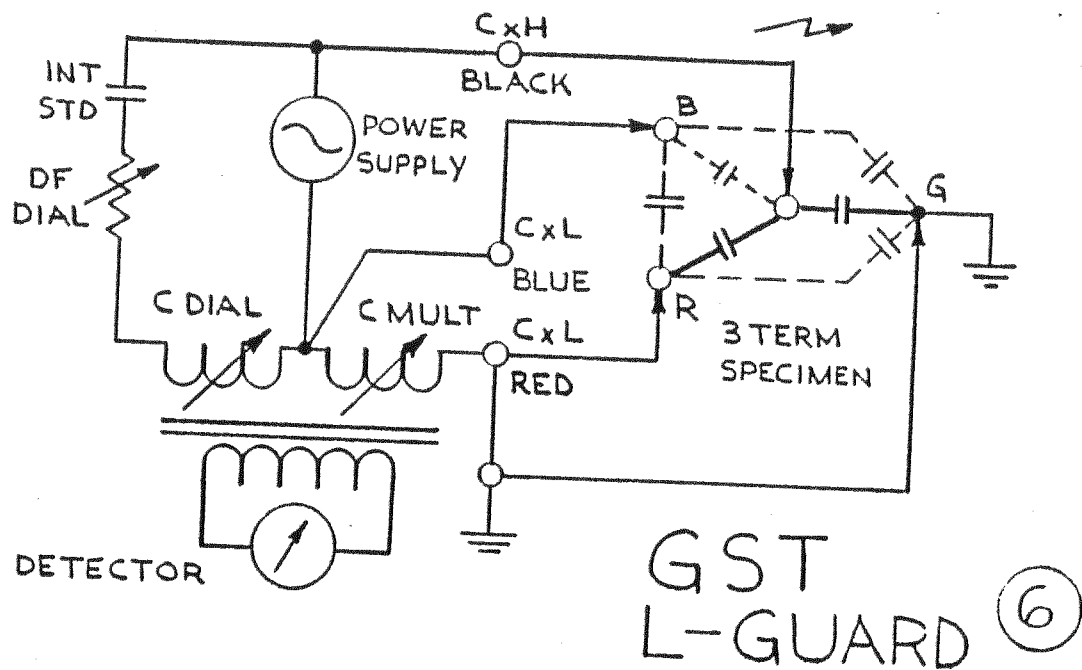
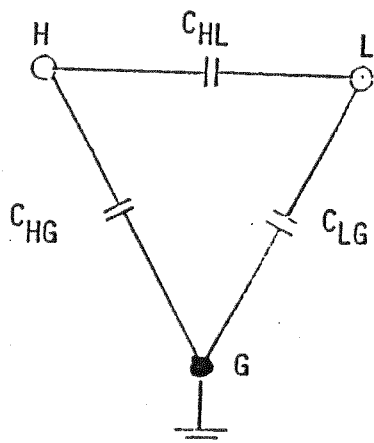


FIGURE 7c: CONNECTION FOR TESTING THREE TERMINAL SPECIMEN.

TWO WINDING TRANSFORMER TEST CONNECTIONS

TEST NO.	UST-GST MODE		MEASURES		TEST LEAD CONNECTIONS			REMARKS
	TYPE	POS	CAPACITANCE SYMBOL	BRIDGE SYMBOL	BLACK CxH	RED CxL	BLUE CxL	
1	UST	3	C_{HL}	R	H	L	-	
2	GST G-GND	4	$C_{HL} + C_{HG}$	R+B+G	H	L	-	L at GND
3	GST L-GUARD	5	C_{HG}	G	H	L	-	L at GUARD
4	UST	3	C_{HL}	R	L	H	-	
5	GST L-GND	4	$C_{HL} + C_{LG}$	R+B+G	L	H	-	H at GND
6	GST L-GUARD	5	C_{LG}	G	L	H	-	H at GUARD
7	GST L-GUARD	5	$C_{HG} + C_{LG}$	G	H & L	-	-	
8								
9								
10								

DIAGRAM



H = HIGH VOLTAGE WINDING
L = LOW VOLTAGE WINDING
G = GROUND

MEASUREMENT INTERCHECKS

$$C_1 = C_2 - C_3$$

$$C_4 = C_5 - C_6$$

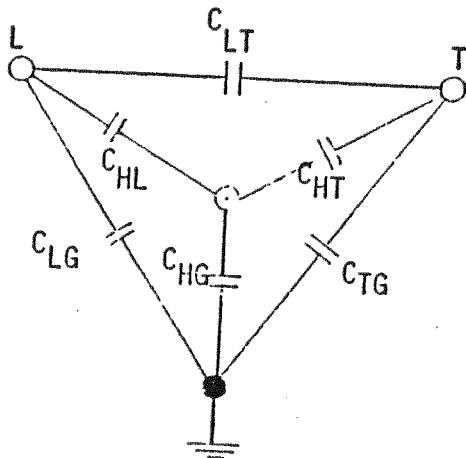
$$DF_1 = C_2 DF_2 - C_3 DF_3$$

$$DF_4 = \frac{C_2 - C_3}{C_5 - C_6} \cdot \frac{C_5 DF_5 - C_6 DF_6}{C_5 - C_6}$$

THREE WINDING TRANSFORMER TEST CONNECTIONS

TEST NO.	UST-GST MODE		MEASURES		TEST LEAD CONNECTIONS			REMARKS
	TYPE	POS	CAPACITANCE SYMBOL	BRIDGE SYMBOL	BLACK CxH	RED CxL	BLUE CxL	
1	UST	3	C_{HL}	R	H	L	T	
2	GST L-GUARD	6	$C_{HL} + C_{HG}$	R + G	H	L	T	T at GUARD L at GND
3	GST L-GUARD	5	C_{HG}	G	H	L	T	L & T at GUARD
4	UST	3	C_{LT}	R	L	T	H	
5	GST L-GUARD	6	$C_{LT} + C_{LG}$	R + G	L	T	H	H at GUARD T at GND
6	GST L-GUARD	5	C_{LG}	G	L	T	H	T & H at GUARD
7	UST	3	C_{HT}	R	T	H	L	
8	GST L-GUARD	6	$C_{HT} + C_{TG}$	R + G	T	H	L	L at GUARD H at GND
9	GST L-GUARD	5	C_{TG}	G	T	H	L	H & L at GUARD
10	GST L-GUARD	5	$C_{HG} + C_{LG} + C_{TG}$	G	H+L+T	-	-	

DIAGRAM



H = HIGH VOLTAGE WINDING
L = LOW VOLTAGE WINDING
T = TERTIARY WINDING
G = GROUND

MEASUREMENT INTERCHECK

$$C_1 = C_2 - C_3$$

$$C_4 = C_5 - C_6$$

$$C_7 = C_8 - C_9$$

$$DF_1 = \frac{C_2 DF_2 - C_3 DF_3}{C_2 - C_3}$$

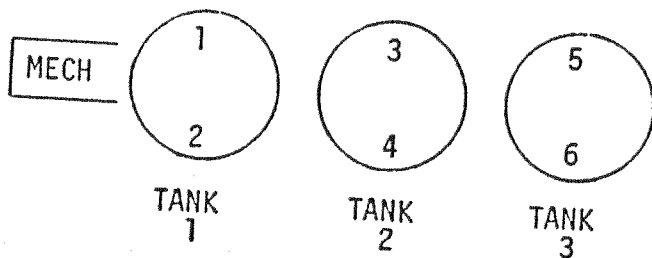
$$DF_4 = \frac{C_5 DF_5 - C_6 DF_6}{C_5 - C_6}$$

$$DF_7 = \frac{C_8 DF_8 - C_9 DF_9}{C_8 - C_9}$$

CIRCUIT BREAKER (OIL TYPE) TEST CONNECTIONS

TEST NO.	UST-GST MODE		MEASURES		TEST LEAD CONNECTIONS			REMARKS
	TYPE	POS	CAPACITANCE SYMBOL	BRIDGE SYMBOL	BLACK CxH	RED CxL	BLUE CxL	
1	GST L-GUARD	5	C_{1G}	G	1	2	-	2 at GUARD
2	GST L-GUARD	5	C_{2G}	G	2	1	-	1 at GUARD
3	GST L-GUARD	5	C_{3G}	G	3	4	-	4 at GUARD
4	GST L-GUARD	5	C_{4G}	G	4	3	-	3 at GUARD
5	GST L-GUARD	5	C_{5G}	G	5	6	-	6 at GUARD
6	GST L-GUARD	5	C_{6G}	G	6	5	-	5 at GUARD
7	GST L-GUARD	5	$C_{1G} + C_{2G}$	G	1 or 2	-	-	
8	GST L-GUARD	5	$C_{3G} + C_{4G}$	G	3 or 4	-	-	
9	GST L-GUARD	5	$C_{5G} + C_{6G}$	G	5 or 6	-	-	
10								

DIAGRAM



CIRCUIT BREAKER OPEN: BUSHING TESTS
CIRCUIT BREAKER CLOSED: TANK TESTS

MEASUREMENT INTERCHECK

$$C_7 = C_1 + C_2$$

$$C_8 = C_3 + C_4$$

$$C_9 = C_5 + C_6$$

$$DF_7 = \frac{C_1 DF_1 + C_2 DF_2}{C_1 + C_2}$$

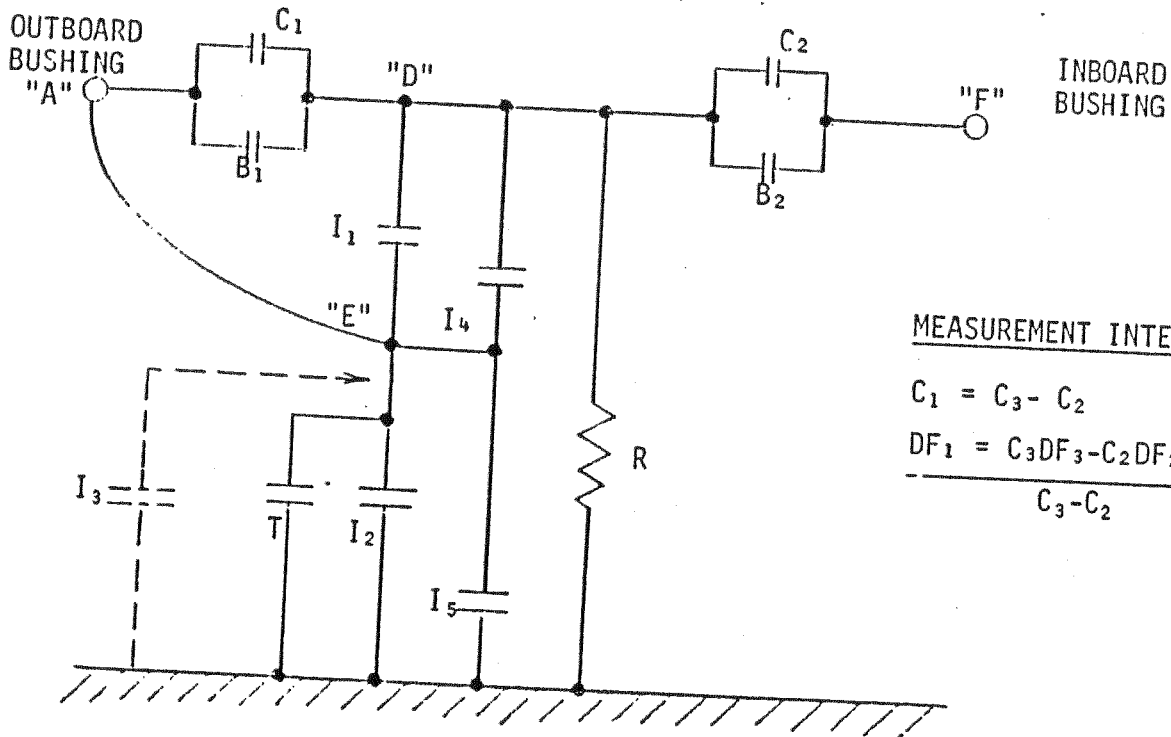
$$DF_8 = \frac{C_3 DF_3 + C_4 DF_4}{C_3 + C_4}$$

$$DF_9 = \frac{C_5 DF_5 + C_6 DF_6}{C_5 + C_6}$$

CIRCUIT BREAKER (AIR BLAST TYPE) TEST CONNECTIONS

TEST NO.	UST-GST MODE		MEASURES		TEST LEAD CONNECTIONS			REMARKS
	TYPE	POS	CAPACITANCE SYMBOL	BRIDGE SYMBOL	BLACK CxH	RED CxL	BLUE CxL	
1	UST	3	$C_2 + B_2$	R	D	F	A	A at GND
2	UST	2	$C_1 + B_1 + I_1$	B	D	F	A	F at GND
3	UST	1	$C_2 + B_2 + C_1 + B_1 + I_1$	R + B	D	F	A	
4	GST L-GUARD	5	R(or $R + I_3$)	G	D	F	A	F&A at GUARD
5*	GST L-GUARD	6	$I_2 + T$	R + G	A	F	D	D at GUARD F at GROUND

*Test performed only on units with current transformer.



MEASUREMENT INTERCHECK

$$C_1 = C_3 - C_2$$

$$DF_1 = \frac{C_3 DF_3 - C_2 DF_2}{C_3 - C_2}$$

- B₁ & B₂-----Entrance Bushing
- C₁ & C₂-----Grading Capacitors
- I₁-----Upper Insulator
- I₂-----Lower Insulator
- I₃-----Insulator for units W/O current transformer.
- R-----Glass fiber air supply tube, oper. rods & wood tie rods.
- T-----Current transformer insulation
- I₄ & I₅-----Protective glass fiber tube which encloses R. Tube is split at Point E with metal guard ring.

TRANSFORMER, AIR BREAK CIRCUIT BREAKER, & BUSHING TEST CAPACITANCE AND DISSIPATION FACTOR MEASUREMENTS

DATE _____

TEST BY _____

TEMP AMB _____

% RH _____

WEATHER _____

TEMP EQPT _____

COMPANY _____

TEST LOCATION _____

EQPT. IDENT. _____

BUSHING MFR. _____ TYPE _____

C.B. MFR. _____ TYPE _____ kV _____

SERIAL # _____

XFMR MFR. _____ TYPE _____ kV _____

SERIAL # _____

TEST NO.	INSULATION TESTED	TEST MODE	TEST		CAPACITANCE			% D.F.				REMARKS
			kV	mA	DIAL RDNG	MULTR	CAP (pF)	DIAL RDNG	MULTR	MEAS %	20°C %	
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												

DIAGRAM

REMARKS

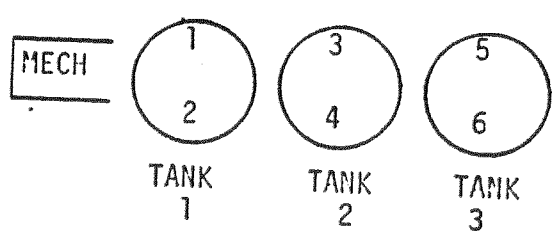
CIRCUIT BREAKER TEST (OIL TYPE)
CAPACITANCE & DISSIPATION FACTOR MEASUREMENTS

COMPANY _____
 TEST LOCATION _____
 EOPT. IDENT _____
 BUSHING MFR. _____ TYPE _____
 C.B. MFR. _____ TYPE _____ kV _____

DATE _____
 TEST BY _____
 TEMP AMB _____
 % RH _____
 WEATHER _____
 TEMP TANK #2 _____
 SERIAL # _____

TEST NO.	INSULATION TESTED	TEST MODE	TEST		CAPACITANCE			% D.F.				REMARKS
			kV	mA	DIAL RDNG	MULTR	CAP (pF)	DIAL RDNG	MULTR	MEAS %	20°C %	
1	BSHG #1											
2	BSHG #2											
3	BSHG #3											
4	BSHG #4											
5	BSHG #5											
6	BSHG #6											
7	TANK #1											
8	TANK #2											
9	TANK #3											
10	OIL #1											
11	OIL #2											
12	OIL #3											

DIAGRAM



REMARKS

C.B. Open: Bushing Tests
 C. B. Closed: Tank Tests

SECTION J

Trouble Shooting and Repair

1. GENERAL

Should the bridge and power supply combination cease to function properly it is desirable to determine if the difficulty lies in the bridge, the power supply, or the interconnections. The best procedure in locating the difficulty is to set up the instrument to measure dissipation factor according to G2, and then to use procedure H2 to measure a known capacitor. A length of high voltage cable with the ends properly stripped and terminated has been found suitable for this application.

- 1.1 Should the power supply be delivering the proper voltage (as indicated on the voltmeter and milliammeter) and the bridge appears to be out of range (that is multiplier of 0.01 and dials of 11+11) it signifies that the bridge is not receiving the charging current from the standard capacitor (CN) located in the power supply section. Check the CN cable and connectors for shorts or open circuits. Should this not be successful, follow procedure J2 for checking out the bridge.

- 1.2 Should the null detector appear to be dead, check the fuse on rear panel, and the operation of reversing switch. If condition remains unchanged, follow section K.

2. Bridge

This procedure is designed to determine if it is necessary to open the bridge to perform necessary repairs.

- 2.1 With the bridge disconnected from the power supply, plug the bridge in to a convenient outlet of 120 volts (or 220 volts for 50 Hz models).
- 2.2 Set detector phase to C
gain to midway
suppressor range to low
- 2.3 Rotate suppressor C dial and observe any deflection on the null indicator.
- 2.4 Set detector phase to DF. Rotate suppressor DF dial and observe any deflection on the null indicator.
- 2.5 Should deflection not be observed in 2.3 or 2.4 - follow procedure K to repair instrument.

- 2.6 Should deflection be observed in both 2.3 and 2.4, connect the shell of the C_N connection to the shell of the C_X connector. Apply some charging current to the instrument by connecting both the C_N and the C_X connectors to 120 volts through two 1000 pF, 600 volt capacitors.
- 2.7 Using procedure H2 balance the instrument. Assuming that the two capacitors are of equal value and similar dissipation factor, the bridge should read 100 with the multiplier on 1 pF, 50 with the multiplier on 2 pF, or 20 with the multiplier on 5 pF. The dissipation factor should read near zero. If it is possible to perform the above, it indicates that the bridge is probably in good working order.

SECTION K

Repair, Adjustment and Calibration

1. Bridge Repair and Adjustment

Should it be determined from section J that repair to the bridge is required, follow the procedure below.

1.1 Unless qualified personnel and required equipment is available, it may be advisable to return the instrument to the manufacturer or agent.

1.2 Equipment required:

- a. Oscilloscope with external triggering.
- b. Standard Capacitors.
- c. Standard Resistors.
- d. 22 pin extension card.
- e. Multimeter.
- f. Resistance Bridge or Meter.
- g. Capacitance Bridge.

1.3 Remove instrument from case and remove protective cover.

1.4 Remove all circuit cards. Connect shell of CN connector to the shell of the CX connector using a suitable clip.

1.5 Plug the instrument to a convenient outlet of 120V (220 volts for 50 Hz models).

1.6 Measure the presence of 36 volts A.C. between pins 9 and 10 of P.R. card socket, also presence of 18 volts A.C. between each pin (9 and 10) and chassis.

Note: It is necessary to remove the power from the instrument before any circuit cards are plugged in or removed from their sockets. Failure to comply may result in damage to components.

1.7 Using the extension card, plug the OI-60-PR card into its socket.

1.8 Check for presence of voltage across filter capacitors, C1, Cs (25 volts).

1.9 Check for presence of +15 volts on pins 20 and 21, and -15 volts on pins 2 and 3.

- 1.10 Replace any rectifiers, capacitors or integrated circuits that may be necessary so that the +15 volts are obtained.
- 1.11 Connect scope input to the line and synchronize to line as shown in Trace (1) using 2 ms per division horizontal sweep.
- 1.12 Check voltage at TPI. The phase of this voltage should change as the sync control on the bridge is varied. (Leave the sync control in such a position that the peak of the wave is symmetrical about the vertical centre line of the scope trace). See Trace (2).
- 1.13 Check the voltage on pin 12 of the card. Voltage should be 16V p-p, and out of phase with voltage in 1.12. Adjust trimmer for tuning and phase position if required. See Trace (3).
- 1.14 Check the voltage on pin 15 of the card. Voltage should be 16V p-p, and lagging pin 12 by 90 degrees. See Trace (4).
- 1.15 Check voltage on TP2. With the detector phase switch in the "C" position voltage should be 16V p-p and out of phase with pin 12. In the "DF" position voltage should be 16V p-p and out of phase with pin 15. See Trace (5) and Trace (6).
- 1.16 Replace any components or integrated circuits that may be necessary to obtain waveforms as shown in Traces (1) to (6) inclusive.
- 1.17 Plug CB-60-PR in its socket, and plug in CB-60-S on top of the card extension. Remember to remove power before installing circuit cards.
- 1.18 Check for +15 volts on pin 21 and 7 and -15 volts on pin 2 and 16. If voltages are not present, it indicates a possible short or faulty integrated circuit on card CB-60-S.
- 1.19 Check voltage on pin 12. It should be the same as pin 12 of CB-60-PR. See Trace (3).
- 1.20 Check voltage on TP3. Voltage should be 28V p-p, square wave and out of phase with pin 12. See Trace (7).
- 1.21 Check voltage on TP4. Voltage should be a 15V p-p saw tooth, leading TP3 by 90 degrees. See Trace (8).
- 1.22 Check voltage on pin 19. Voltage should be 12V p-p, sinusoidal, and out of phase with TP4. Adjust trimmer for proper phasing if required. See Trace (9).

- 1.23 Check voltage on pin 18. Voltage should be the same as pin 19, but 180 degrees out of phase.
- 1.24 Check voltage on pin 17. Voltage should be in-phase or out of phase with Trace (9) and vary as the DF interference suppressor control is adjusted. Set voltage close to zero.
- 1.25 Check voltage on pin 4. Voltage should be 12V p-p and leading pin 19 voltage by 90 degrees. See Trace (10).
- 1.26 Check voltage on pin 5. Voltage should be same as pin 4, but 180 degrees out of phase.
- 1.27 Check voltage on pin 6. Voltage should be in-phase or out of phase with Trace (10) and vary with the "C" interference suppressor control. Set voltage near zero.
- 1.28 Replace any components that may be necessary to make the test points comply with requirements.
- 1.29 Plug in CB-60-S in its socket, and plug in CB-60-D on top of extension card.
- 1.30 Check for +15 volts on pin 20 and for -15 volts on pin 3. Absence of voltage usually indicates a short or a defective integrated circuit.
- 1.31 Check voltage on pin 6 (input). Voltage should be nearly zero. Try moving "C" and "DF" interference suppressor controls and observe voltage.
- 1.32 With the "C" interference control and gain control fully clockwise, amplitude should be:

10 mV p-p	-	in Lo position
100 mV p-p	-	in Med position
- 1.33 Check voltage on PT5. With gain fully clockwise, interference suppressor in Lo position, and "C" zero control fully clockwise, voltage should be about 3V p-p and in phase with the 120 volt supply. Adjust trimmer for tuning and correct phase position if required. See Trace (11).
- 1.34 Adjust "C" and "DF" interference suppressor controls so that voltage at TP5 is zero. Adjust trimmer on synchronous detector bridge so that the null indicator shows zero.
- 1.35 Check if the null indicator remains at zero when "C" interference suppressor control is varied and detector phasing is in "DF". If not, re-adjust tuning (1.33). Similarly check if the null detector remains at zero when "DF" interference suppressor control is varied and detector phasing is in "C".

- 1.30 Plug in CB-60-D directly in its socket.
- 1.37 Plug in CB-60-C directly in its socket.
- 1.38 Apply 120 volts through a polystyrene 1000 pF, 600 volt capacitor to the pin of CN connector.
- 1.39 Using procedure H2, bring the bridge to balance with the interference suppressor in the "off" position. The bridge should balance at 0.00 on any of the multiplier positions.
- 1.40 Apply 120 volts through two polystyrene 1000 pF, 600 volt, capacitors to the CN and CX terminals, simultaneously.
- 1.41 Using procedure H2, bring the Bridge to balance. The bridge should indicate approximately 100 on the 1 pF range, 50 on the 2 pF range, and 20 on the 5 pF range. The dissipation factor should be near zero.
- 1.42 Try balancing the bridge now with the interference suppressor in the Low, then Medium, then High ranges. Reduce gain when using suppressor on higher ranges.

2. Bridge Calibration

There are no adjustments provided that will change the calibration of the capacitance or dissipation factor dials.

The calibration of the Capacitance dials depends solely on the capacitance of the standard capacitor and the ratio of the standard capacitor and the ratio of the balancing transformer.

The calibration of the dissipation factor dials is controlled by the 0.32 uF capacitor on the X10 range, on the 0.032 uF capacitor on the X1.0 range, and the 3200 pF capacitor on the X0.1 range.

The exact value of capacitance required depends on the value of the standard capacitor and stray capacitance. If the bridge is found to read high on DF, then additional capacitance must be added. Similarly if the instrument is found to read low on DF, then some capacitance must be removed from the circuit.

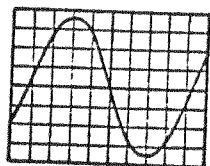
The calibration of the instrument should be performed only in the UST configuration using a lossless standard capacitor. To generate losses in the standard capacitor, resistors should be used in series with it. The dissipation factor (DF) of an R-C combination can be calculated from:

$$DF = 377 RC \cdot 10^{-10} \text{ at } 60 \text{ Hz}$$

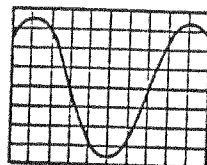
where DF = dissipation factor, in percent
 R = resistance in ohms
 C = capacitance in picofarads

Prior to performing any calibration with a standard capacitor the resistance of the DF resistors "R" and the capacitance "C" should be measured.

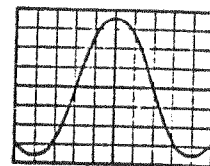
- 2.1 The resistance of the DF resistors can be measured with a suitable ohmmeter or bridge between the pin and shell of the C_N connector.
- 2.2 Set Capacitance dials to 0.0.
- 2.3 The resistance of "R" should be 825 ohms, $\pm 1\%$ for each step of the switch, and 1000 ohms on the slide wire.
- 2.4 To measure "C", unsolder the wiper on the first capacitance decade switch.
- 2.5 Measure capacitance between pin and shell of C_N connector using a suitable capacitance bridge.
- 2.6 Values of "C" should be 2300 pF, 31200 pF, and 0.320 μ F on the X0.1 X1.0 and X10 ranges respectively.
- 2.7 When a value of 900 pF (100 pF standard + 800 pF strays in cable and wiring) is added to the values in 2.6, then the required capacitances of 3200 pF, 32000 pF and 0.320 μ F are obtained.



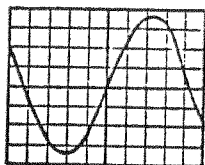
Trace 1
Line
 $V = 50V/div$



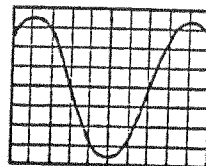
Trace 2
TP-1
 $V = 20V/div$



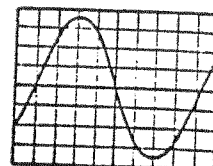
Trace 3
Pin - PR-12
 $V = 2V/div.$



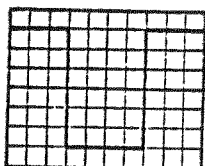
Trace 4
Pin - PR-15
 $V = 2V/div$



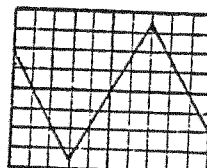
Trace 5
TP-2 (c)
 $V = 2V/div$



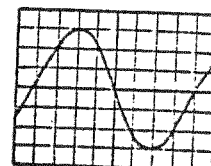
Trace 6
TP-2 (DF)
 $V = 2V/div$



Trace 7
TP-3
 $V = 5V/div$



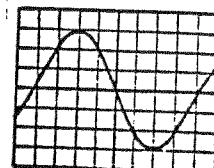
Trace 8
TP-4
 $V = 2V/div$



Trace 9
Pin-S-19
 $V = 2V/div$



Trace 10
Pin - S-4
 $V = 2V/div$



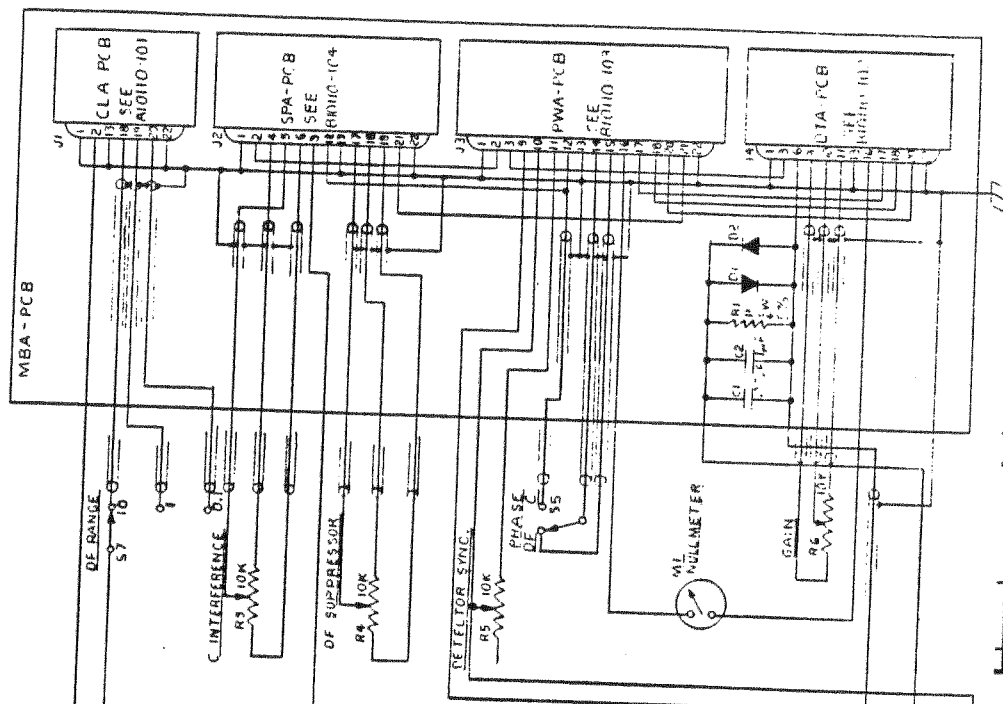
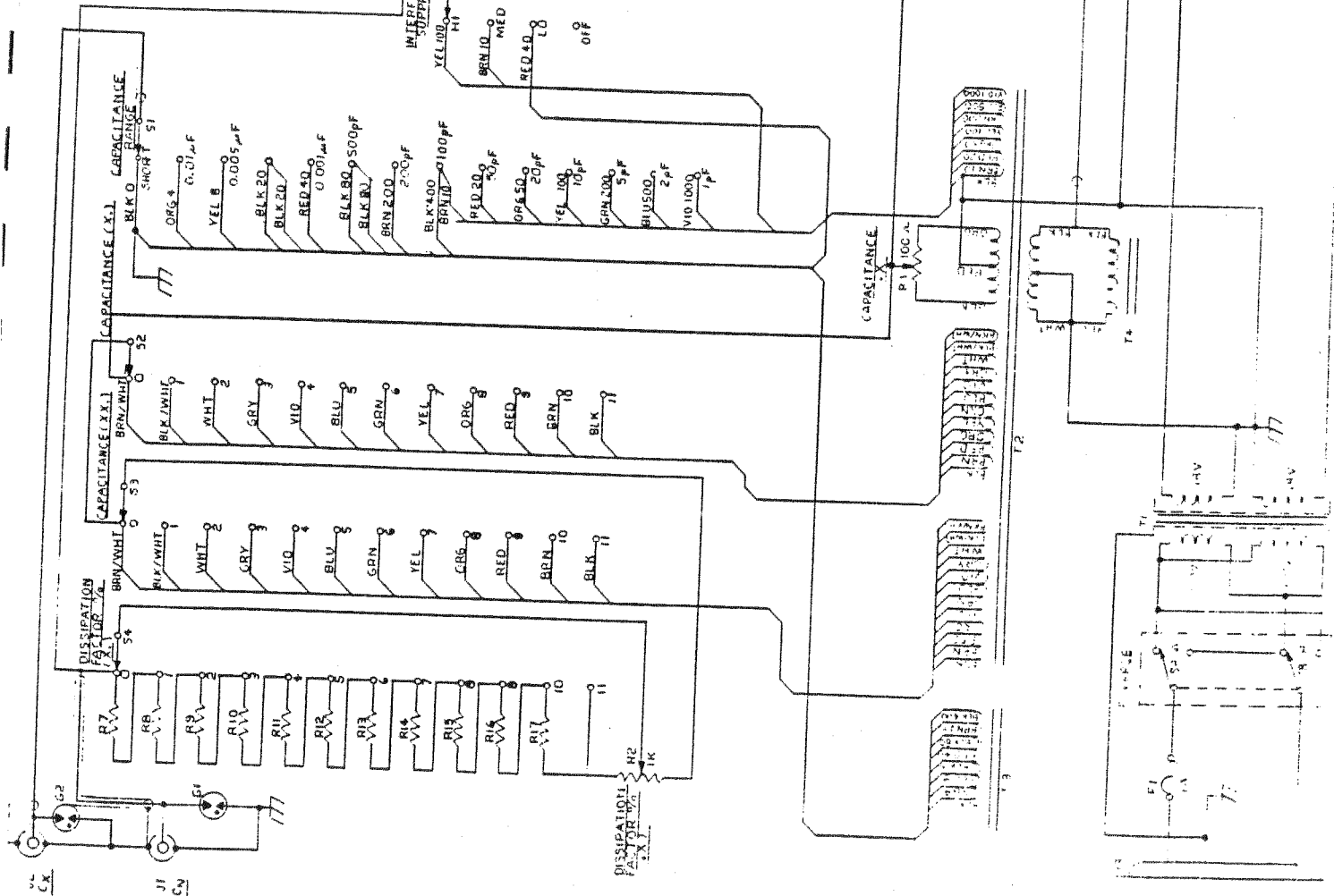
Trace 11
TP-5
 $V = 2V/div$

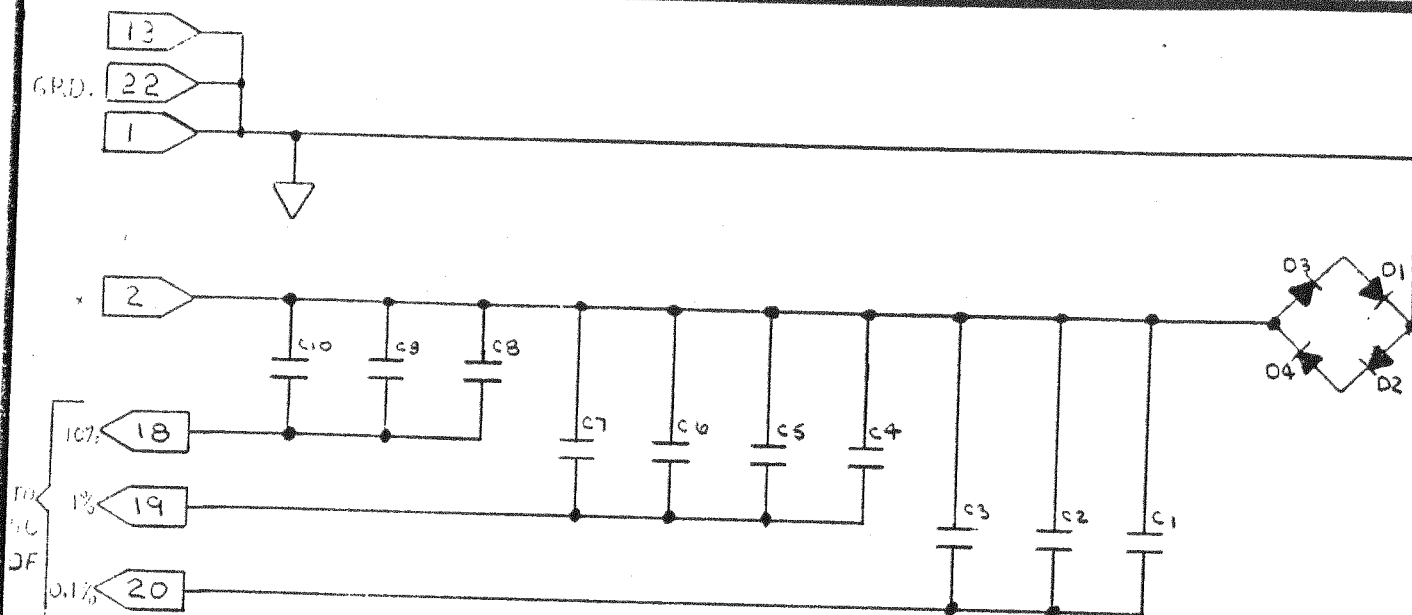
OSCILLOSCOPE TRACES.

Horizontal = 2 ms/div, synchronized to line.

ON

1. ALL DIODES ARE IN4001
2. ALL RESISTORS ARE 825Ω, $\frac{1}{4}$ WATT AND 5% UNLESS OTHERWISE SPECIFIED
3. FOR 240V AND 50HZ SERVICE CHANGE C1 TO C1F AND CHANGE PRIMARY WINDING ON T1 FROM PARALLEL TO SERIES

[illegible]

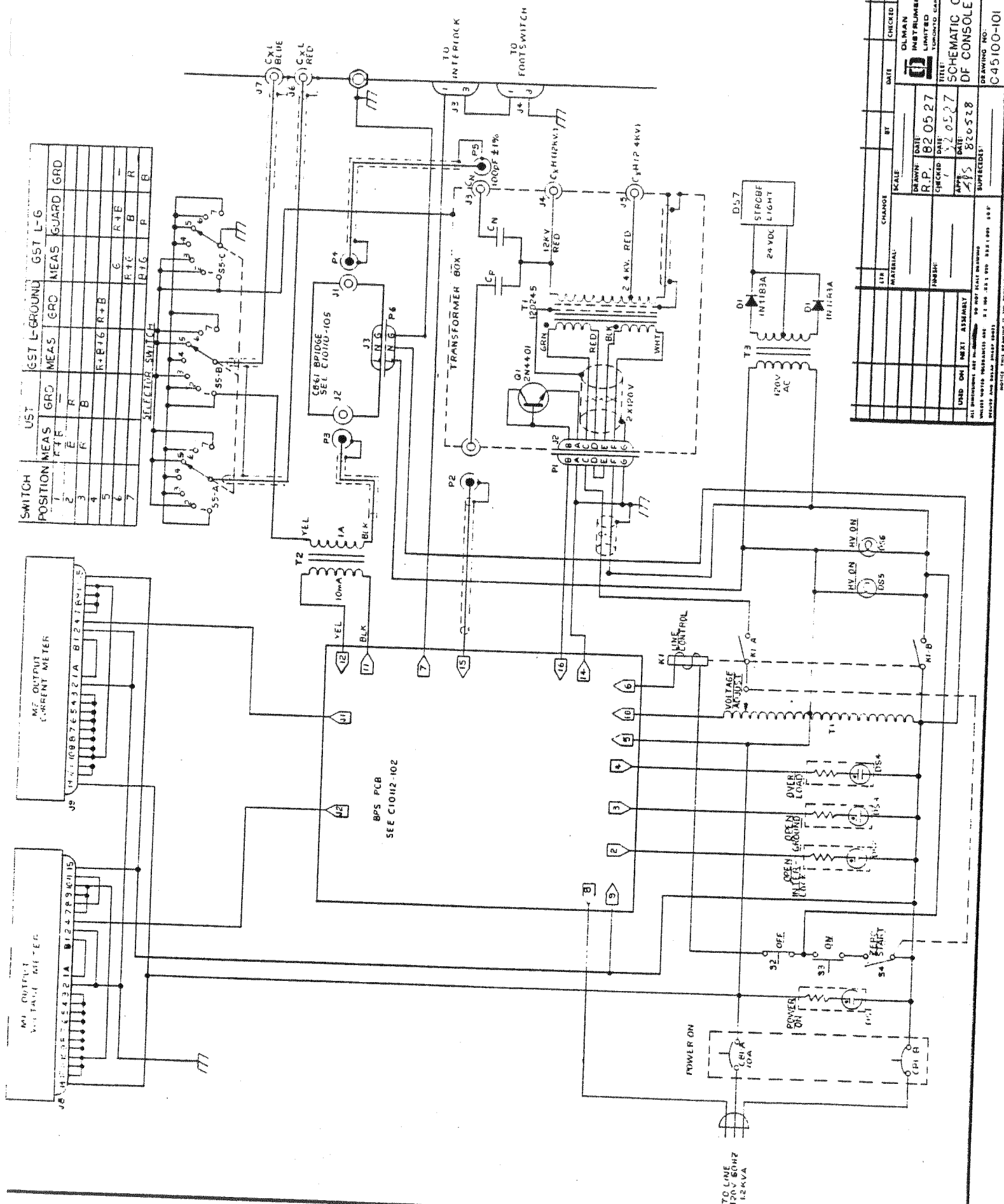


- NOTES
1. ALL DIODES ARE 1N4148
 2. CAPACITOR VALUES (NOMINAL)

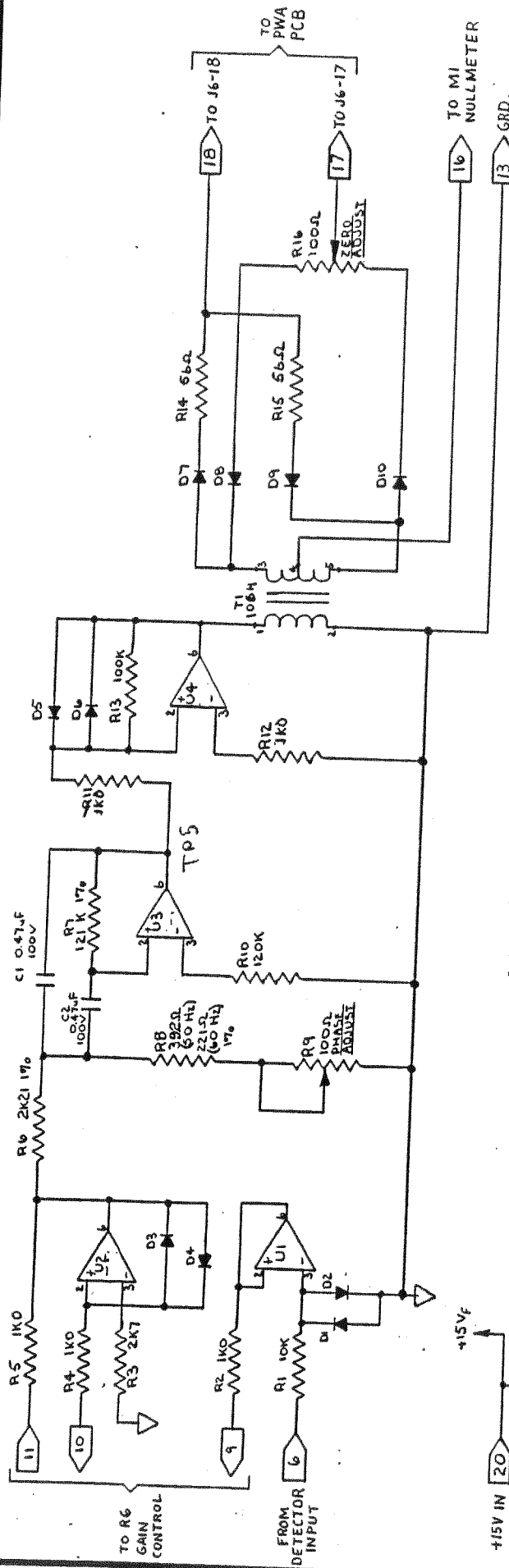
	50Hz	60Hz
C1	1nF/630V	1nF/630V
C2	1n8F/630V	1n2F/630V
C3	50pF/630V	XNU
C4	1nF/630V	1n2F/630V
C5	30nF/63V	30nF/63V
C6	3nF/630V	XNU
C7	3n6F/630V	XNU
C8	160nF/63V	160nF/63V
C9	160nF/63V	160nF/63V
C10	62nF/63V	XNU

LTR		CHANGE		BY	DATE	CHECKED	APPR.
MATERIAL:		SCALE:		DRAWN: BG		DATE: 82 05 12	
FINISH:		CHECKED: DC		DATE: 82 05 25		TITLE: SCHEMATIC	
USED ON NEXT ASSEMBLY		APPR: 425		DATE: 82 05 27		CLA PCB	
ALL DIMENSIONS ARE IN ~~INCHES~~ DO NOT SCALE DRAWING				SUPERCEDES:		DRAWING NO: A10110-101	
UNLESS NOTED TOLERANCES ARE: .X ±.100 .XX ±.020 .XXX ±.005 ±0.3°						REV	
DEBURR AND BREAK SHARP EDGES							

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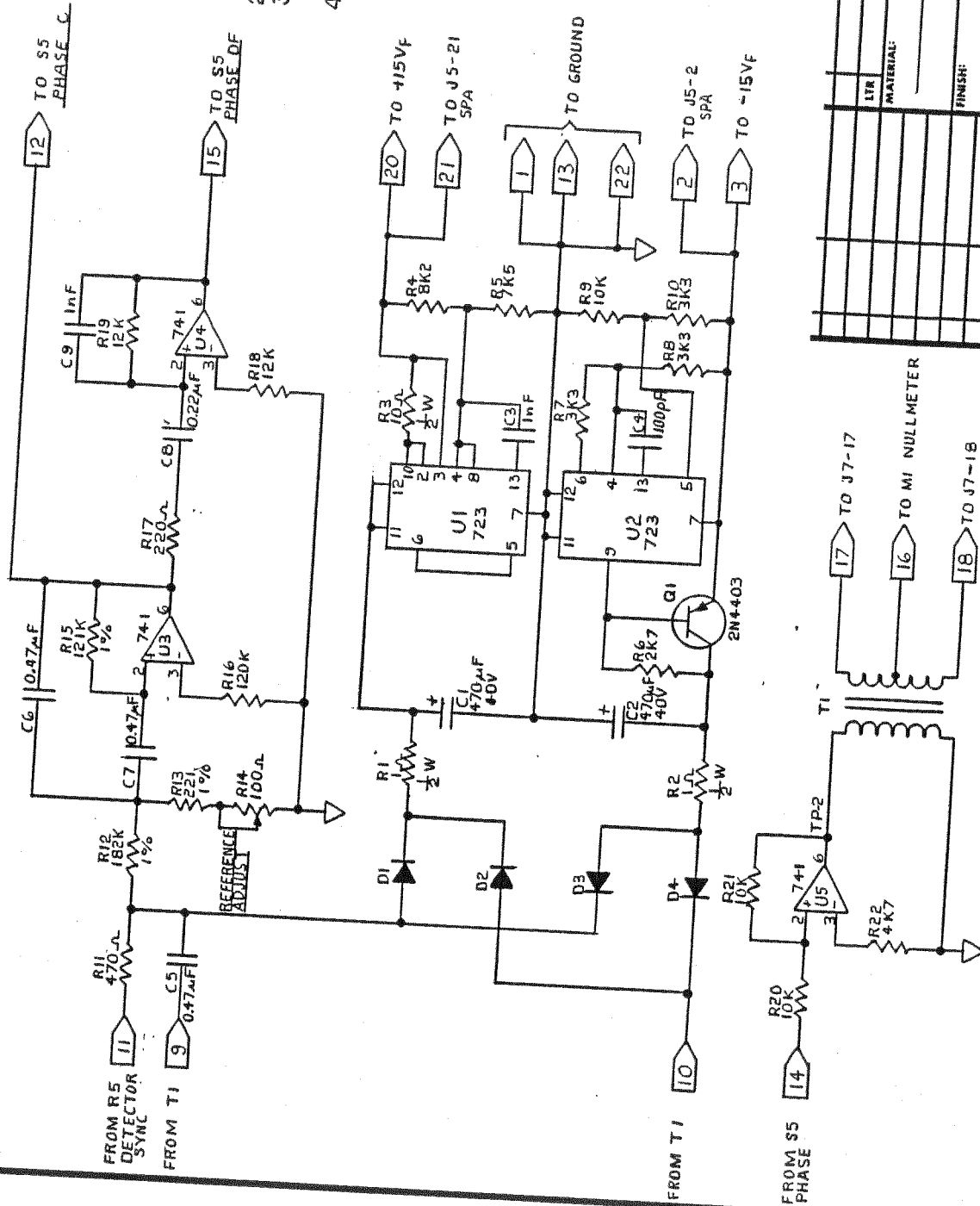
USED ON	NEXT ASSEMBLY	ALL INFORMATION IS UNCLASSIFIED UNLESS NOTED OTHERWISE AND REVIEW AND DISSEM. (PUB. 2000.1) NOTICE: THIS PAGE IS UNCLASSIFIED	DATE	BY	SCALE	CHANGE	DATE	CHECKED	APPRO
			DATE: 82 05 27						
			CHECKED: 1						
			DATE: 82 05 27						
			APPRO: JJS						
			DATE: 82 05 28						
			SUPERCIDES:						
			DRIVING NO. C45100-101						



- NOTES
1. ALL DIODES ARE IN4148
 2. ALL RESISTORS ARE 1/4W AND 5% UNLESS STATED OTHERWISE
 3. ALL IC'S ARE MC1741CP WITH PIN 7 TO +15V AND PIN 4 TO -15V

ETR	SCALE	DATE	BY	CHECKED	APPR.
A	R8 (60 Hz) WAS 332Ω	8-2-08	19	112W	4LS
MATERIAL:		OLMAN INSTRUMENTS LIMITED TORONTO CANADA			
FINISH:		DRAWN: DATE: BG 82 05 12			
USED ON		CHECKED: DATE: OC 82 05 21			
NEXT ASSEMBLY		APPR: 5LS			
ALL DIMENSIONS ARE IN INCHES. DO NOT SCALE DRAWING UNLESS NOTED TOLERANCES ARE: .X 1.000 .XX 1.020 .XXX 1.005 DESIGNS AND BREAK SHARP EDGES		DATE: 820527			
SUPERCEDES:		TITLE: SCHEMATIC			
DRAWING NO: B10110-102		REV: A			

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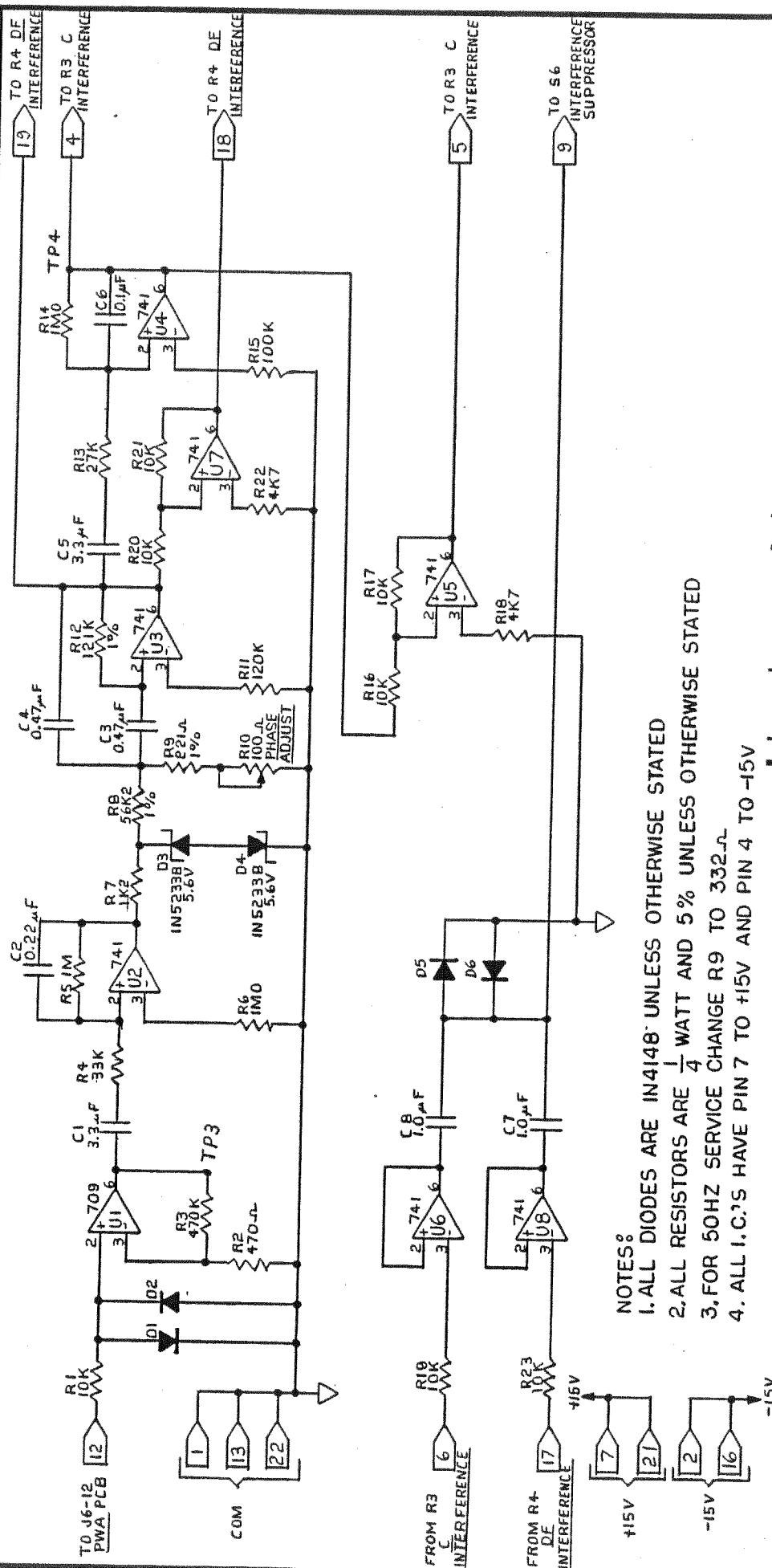
NOTES:

1. ALL RESISTORS ARE $\frac{1}{4}$ WATT AND 5% UNLESS OTHERWISE STATED
2. ALL DIODES ARE 1N4001
3. IC'S U3, U4, ARE MC1741CP WITH PIN 7 TO +15V AND PIN 4 TO -15V
4. FOR 50Hz SERVICE CHANGE R13 TO 332k AND 1%

DATE	BY	SCALE	CHANGE	DATE	CHECKED	APPR.
DATE: 820514						
CHECKED: 820521						
APPR: 820527						
SUPERCEDES:						

DRAWN: R.P.		DATE: 820514		OLMAN INSTRUMENTS LIMITED TORONTO CANADA	
CHECKED: 820521		DATE: 820521		TITLE: SCHEMATIC	
APPR: 820527		DATE: 820527		PWA PCB	
SUPERCEDES:		DATE: 820527		DRAWING NO: B10110-103	
ALL DIMENSIONS ARE IN MILLIMETERS DO NOT SCALE DRAWING		UNLESS NOTED SOURCES ARE: .X 1.100 .X 1.000 .X 1.005 10.0		REV	

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- NOTES:
1. ALL DIODES ARE IN4148 UNLESS OTHERWISE STATED
 2. ALL RESISTORS ARE $\frac{1}{4}$ WATT AND 5% UNLESS OTHERWISE STATED
 3. FOR 50HZ SERVICE CHANGE R9 TO 332 Ω
 4. ALL I.C.'S HAVE PIN 7 TO +15V AND PIN 4 TO -15V

A		R.P. 82-05-19		HLS	
LTR	CHANGE	BY	DATE	CHECKED	APPR.
MATERIAL:		SCALE:		OLMAN INSTRUMENTS LIMITED TORONTO CANADA	
DRAWING: DATE: R.P. 82-05-18		CHECKED: DATE: 0 C 82-05-21		TITLE: SCHEMATIC	
FINISH:		APPR: DATE: 82-05-27		SPA PCB	
USED ON: NEXT ASSEMBLY		SUPERCEDES:		DRAWING NO: BIO110-104	
ALL DIMENSIONS ARE IN INCHES. DO NOT SCALE DRAWING. UNLESS NOTED TOLERANCES ARE: .X 1.00 .XX 1.00 .XXX 1.00 10.0"		DESIGN AND BREAK SHARP EDGES		REV A	

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NOTE

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CB61A TEST SET.

NEW PAGES WITH PROPER PHOTOGRAPHS WILL
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AVAILABLE.